

McCORMICK & BAXTER CREOSOTING COMPANY

Site Water and Soil Investigation

Interim Report

Submitted to

OREGON DEPARTMENT
OF
ENVIRONMENTAL QUALITY

Prepared by
McCormick & Baxter Creosoting Company
and
CH2M HILL
January 1985

Doc ID: 32501
Barcode: 1033838

McCORMICK & BAXTER CREOSOTING COMPANY

Site Water and Soil Investigation

Interim Report

Submitted to

OREGON DEPARTMENT
OF
ENVIRONMENTAL QUALITY

Dept. of Environmental Quality

RECEIVED
JAN 11 1985

NORTHWEST REGION

Prepared by
McCormick & Baxter Creosoting Company
and
CH2M HILL
January 1985

CONTENTS

	<u>Page</u>
1 Summary	1-1
2 Introduction	2-1
Wood Preservation and Environmental Concerns	2-1
The McCormick & Baxter Plant	2-2
Site Investigation and Assessment	2-3
3 Plant Site and Operations	3-1
Site Description	3-1
Plant and Process Description	3-5
Waste Management	3-9
Recent Inspections and Maintenance	3-11
4 Preliminary Investigation	4-1
Sampling and Testing Procedures and Results	4-2
Site Characterization	4-14
Preliminary Exposure Assessment	4-21
5 Future Work	5-1
Future Site Investigations	5-1
RI/FS Process	5-4
Remedial Investigation	5-5
Feasibility Study	5-5
Schedule	5-8
6 Bibliography	
Appendix A. Cost-Benefit Analysis for Wood Preservatives	
Appendix B. Boring Logs	
Appendix C. Laboratory Results	
Appendix D. Degradation of Wood Treatment Wastes	
Appendix E. Remedial Action Alternatives	

TABLES

	<u>Page</u>
3-1 Water Use in McCormick & Baxter Vicinity	3-4
4-1 Monitoring Well Screened Interval	4-8
4-2 Water Level Data for Selected Dates	4-9
5-1 Schedule of Future Activities	5-9

FIGURES

3-1 Vicinity Map	3-2
3-2 Site Plan	3-7
4-1 Monitoring Well and Boring Hole Locations	4-3
4-2 Groundwater Contour Map	4-11
4-3 Groundwater Quality Map (Sheet 1)	4-15
4-3 Groundwater Quality Map (Sheet 2)	4-17

CVR9/044

SUMMARY

Section 1 SUMMARY

Treating wood with preservatives is a centuries-old practice that has made wood an essential building product by greatly increasing its useful life and extending the nation's timber resources. Recently a 6-year investigation by EPA, USDA, and a number of land-grant universities concluded that there is no cost-effective alternative to wood-treating preservatives, and that the benefits derived from their use exceed any risks.

In July 1984, the EPA issued their final position paper on the registration of wood preservatives that concluded the benefits for commercial use of these wood preservatives are substantial and that their continued commercial use is not likely to result in any significant exposure to humans or the environment. The EPA prescribed a number of low-cost precautions (e.g., wearing gloves or other common protective clothing) for specific commercial wood-preserving operations as conditions accompanying continued registration. The EPA considers these precautions and other common safety procedures to be sufficient protection for workers who are exposed to the preservatives on a daily basis. Several groups have indicated that EPA's methodology was too conservative claiming that even these restrictions on use are unnecessarily stringent. It intuitively follows that offsite health risks surrounding a commercial facility would be greatly reduced from those onsite.

McCormick & Baxter Creosoting Co. (M&B) is a family-owned company that was founded in the early 1940's to meet the need for treated wood products during World War II. The production of treated wood products is the company's only business. M&B-treated wood products include dimensional lumber, plywood, utility poles, piling, timbers, railroad ties, crossarms, glue laminated materials, and all-weather wood foundations. The Portland plant now employs 70 to 90 people and treats approximately 20 million board feet of lumber and 12 million board feet of round stock per year.

In August 1983, McCormick & Baxter voluntarily initiated a preliminary site investigation because the company was concerned about the potential for offsite environmental impacts resulting from the plant's past operations. This interim report presents the findings of the investigative work completed to date and describes further actions to be taken. The preliminary findings indicate no short-term imminent risks to public health or the environment from the areas of site contamination addressed in this report. Therefore, no emergency action is needed.

The purpose of the continuing investigation is to evaluate the possibility of long-term environmental or health risks from these sources and to further define and quantify the long-term potential for offsite migration. Worker health and safety are not addressed because extensive EPA research on worker safety has shown no risk to the health of onsite personnel if proper precautions are followed, as they are at the M&B plant.

PLANT SITE AND OPERATIONS

The McCormick & Baxter plant is located on a dredged sand fill on the east bank of the Willamette River at river mile 7. The 58-acre site is located in a heavy industrial area bordered on the northwest by the Burlington Northern Railroad, on the northeast by the Union Pacific Railroad and a 100-foot bluff, on the southeast by Riedel International, and on the southwest by the Willamette River.

M&B's treated wood products plant includes untreated log and pole storage; peeler (log debarker); untreated wood drying facilities (dry kiln and pole dryers); treating cylinders (retorts); treated product storage and shipping; fuel and wood preservative storage; boiler room; office; laboratory; and wood preservative recovery and wastewater treatment units. M&B uses three types of pressure processes in the application of wood preservatives. These are: 1) creosote, creosote mixed with oil, and pentachlorophenol in oil treatment; 2) chemonite ammonical copper arsenate (ACA) waterborne treatment; and 3) Cellon (penta in liquified petroleum gas).

Since the mid-1960s, the plant has been regulated by state and local agencies. The company is committed to operating in an environmentally responsible manner and in compliance with environmental regulations. In its 40 years of operation, the M&B plant has been in compliance with environmental regulations and in some areas has been a leader in the industry. Waste management at the plant has changed noticeably as a result of technological developments and changing federal, state, and local environmental regulations. A brief chronological summary of M&B waste management practices, process improvements, and environmental inspection program is shown in Section 3. Under standard operating procedures, the amount of process wastes now being released into the environment is extremely low.

PRELIMINARY INVESTIGATION

Since August 1983, M&B has drilled 17 borings/monitoring wells onsite to sample site soil and groundwater. Initial groundwater, surface, and soil sample analyses along with information regarding past and present plant activities provide sufficient information to form a preliminary

characterization of the site. Soil and water samples have been analyzed for oil and grease, PCP, PAH's, TOC, copper, chromium, and arsenic. The initial sample analyses suggest that, for most of the site, wood preservatives in the ground-water and subsurface soils are primarily the result of past operating practices.

The four potentially significant sources of offsite releases of wood preservatives are as follows:

- o Former Cellon Wash Area
- o Tank Farm
- o Former Waste Disposal Area
- o Site Surface and Stormwater Outfall

The DEQ has been concerned with the potential offsite migration of wood preservative constituents and their impact on the Willamette River. Three periodic samplings of the Willamette River, which included river water and sediments near McCormick & Baxter, have been conducted by the DEQ. Analysis revealed trace levels of some polyaromatic hydrocarbons (PAHs) in the sediments. PAHs, PCP, and other preservatives were not detected in any of the water samples.

FUTURE WORK

McCormick & Baxter is proceeding with a program to continue to reduce the potential offsite releases of wood preservatives through improved point source control. This program includes continued efforts to isolate the wood preservation operations from other plant operations; and an intensified inspection and maintenance program.

In addition to site improvements, McCormick & Baxter will continue to collect information on the presence of wood preservative constituents in the site soils, surface waters, and groundwater to further characterize the site. The characterization is required to more accurately define the long-term potential for offsite exposure of wood preservatives from the site. With the additional information needed to more fully characterize the site, a remedial investigation (RI) and feasibility study (FS) will be prepared. The RI/FS will include a public health evaluation and environmental analysis, similar to those already done for wood preservative chemicals, to determine if any long-term risks exist which exceed health or environmental criteria. If so, it will identify the lowest cost alternative that is technologically feasible in meeting the long-term criteria.

The RI/FS process will also consider the data shown in Appendix D, i.e., that wood preservatives tend to bind tightly to soil and that at lower concentrations in soil and in water, and under suitable environmental conditions, these organic

chemicals have been shown to be readily biodegradable by organisms already existing in the environment. Well over 99-percent biodegradation has been achieved by both aerobic and anaerobic processes. This biodegradation efficiency in water is even higher than that normally achieved with the usual constituents found in domestic sewage. Trace residuals of wood preservative chemicals have also been shown to photo-degrade and to be rapidly excreted in both fish and in mammals, and not to bioaccumulate in the environment.

CVR9/045

Section 2 INTRODUCTION

Treating wood to extend its usability is a centuries-old practice dating back to Biblical times. Traditionally, coal and wood tar products were used as preservatives. The commercial use of creosote and coal tar as wood preservatives began in 1838 in England with the development of a practical pressure-treating process.

Without treatment, few wood products would be in common construction use. Treating wood with preservatives protects wood against attack by fungi, insects, bacteria, and marine borers, and thus increases the useful life of the wood products many times over. For example, wood pressure-treated with pentachlorophenol in oil can last 30 years or more without painting or further treatment in moist conditions where untreated wood has an average life of only about 5 years.

Preservative treatment of wood is also a vital element in extending Northwest timber as a renewable resource. It has been estimated that more than 19 billion board feet of additional timber would need to be cut annually if untreated wood were used in place of treated wood.

WOOD PRESERVATION AND ENVIRONMENTAL CONCERNS

The wood-preserving industry uses three major types of preservatives: creosote, inorganic arsenicals, and pentachlorophenol. Regulatory agencies, state universities, and the wood-treating industry recently completed a 6-year effort comparing the benefits of wood preservatives against any possible risks from use. A process called the Rebuttable Presumptions Against Registration (RPAR) was established by law to identify pesticides whose use might pose risks to man or the environment which outweigh their benefits.

On October 18, 1978, the EPA issued RPARs for all three wood preservatives. In the RPARs, the EPA cited data suggesting that the preservatives could pose a potential for "unreasonable risk to man or the environment." By issuing the RPARs, the EPA solicited responses from registered users and other interested parties. Considerable information was then submitted and detailed consideration was given to the economical, social, and environmental benefits of using the preservatives and the expected risks to humans or the environment.

RPAR respondents (including the U.S. Dept. of Agriculture, the EPA, state land-grant universities, and the American Wood Preservers Institute) reviewed and completed numerous studies regarding the risks and benefits of using these wood preservatives (see Appendix A). USDA 1980 cost figures show

that prohibiting the use of all three preservatives would cost \$4.5 to \$6.3 billion annually. These 1980 studies also state that the exposure risks in using the preservatives were acceptable.

In July 1984, the EPA issued a final position paper on the registration of wood preservatives that concluded the benefits for commercial use of these wood preservatives are substantial and that their continued commercial use is not likely to result in any significant exposure to humans or the environment. The EPA prescribed a number of low-cost precautions (e.g., wearing gloves or other common protective clothing) for specific commercial wood-preserving operations as conditions accompanying continued registration. These precautions and other common safety procedures are considered sufficient protection for workers who are exposed to the preservatives on a daily basis. Use of the preservatives was also restricted to registered users to prevent the possible risk to untrained persons. Interior use was also restricted.

The EPA position paper established that, under proper commercial use, the wood preservatives do not pose an unacceptable risk to workers. It intuitively follows that offsite health risks surrounding a commercial facility would be greatly reduced from those onsite.

THE MCCORMICK & BAXTER PLANT

McCormick & Baxter Creosoting Co. (M&B) is a family-owned company that was founded in the early 1940's to meet the need for treated wood products during World War II. The production of treated wood products is the company's only business. M&B-treated wood products include dimensional lumber, plywood, utility poles, piling, timbers, railroad ties, crossarms, glue laminated materials, and all-weather wood foundations. The Portland plant now employs 70 to 90 people and treats approximately 20 million board feet of lumber and 12 million board feet of round stock per year.

Since the mid-1960s, the plant has been regulated by state and local agencies. The company is committed to operating in an environmentally responsible manner and in compliance with environmental regulations. In its 40 years of operation, the M&B plant has been in compliance with environmental regulations and in some areas has been a leader in the industry. Waste management at the plant has changed noticeably as a result of technological developments and changing federal, state, and local environmental regulations. In the past, bark and wood ends were incinerated, logs and treated poles were stored in the river, and treated process wastewater was discharged to the Willamette River. Today the plant sells its wood residues for fuel and landscaping, evaporates excess process wastewater, and ships its wood

preservative waste materials offsite to approved hazardous waste management facilities. Under standard operating procedures, the amount of process wastes being released into the environment is extremely low.

SITE INVESTIGATION AND ASSESSMENT

In August 1983, McCormick & Baxter voluntarily initiated a preliminary site investigation because the company was concerned about the potential for offsite environmental impacts resulting from the plant's past operations. This initial investigation indicated a potential for offsite migration of wood preservatives from the area once used for waste disposal. As a result of this information, McCormick & Baxter notified the Oregon Department of Environmental Quality (DEQ), the principal environmental agency regulating the plant. In addition, McCormick & Baxter hired CH2M HILL, an environmental consulting engineering firm, to review preliminary findings and conduct a more extensive site investigation. This includes the investigation of past management practices, current operations, and changes needed to maintain state-of-the-art management of the plant's waste materials.

This interim report presents the findings of the investigative work completed to date and describes further actions to be taken. The preliminary findings indicate no short-term imminent risks to public health or the environment from the areas of site contamination addressed in this report. Therefore, no emergency action is needed.

The purpose of the continuing investigation is to evaluate the possibility of long-term environmental or health risks from these sources and to further define and quantify the long-term potential for offsite migration. Worker health and safety are not addressed because extensive EPA research on worker safety has shown no risk to the health of onsite personnel if proper precautions are followed, as they are at the M&B plant.

Since they initiated the site investigation, M&B has maintained open and frequent communication with the DEQ. Their communications have consisted of frequent telephone conversations, meetings, and correspondence. The following is a brief chronological summary of the correspondence among M&B, CH2M HILL, and DEQ over the last 12 months.

December 23, 1983	M&B letter to DEQ, notifying DEQ initiating preliminary site investigation. Requested a meeting with DEQ.
January 6, 1984	DEQ letter to M&B summarizing 1/4/84 meeting and agreed upon activities.

February 14, 1984	CH2M HILL letter to DEQ reporting the status of the preliminary site investigation.
March 30, 1984	DEQ news release that M&B study was being reopened.
April 3, 1984	M&B report to DEQ presenting results of recent soil and water sampling and proposed plan for additional site investigation.
May 8, 1984	DEQ letter to M&B commenting on proposed plan for additional site investigation.
May 29, 1984	M&B letter to DEQ responding to DEQ's letter of May 8, 1984.
June 15, 1984	DEQ letter to M&B acknowledging M&B's letter of May 29, 1984, and requesting DEQ be kept apprised of progress in conducting additional site investigation.
June 28, 1984	CH2M HILL letter to DEQ reporting the status of the additional site investigation.
August 31, 1984	M&B letter to DEQ reporting the status of the additional site investigation.
October 23, 1984	M&B letter to DEQ, reporting the status of the additional site investigation.
January 11, 1985	M&B submittal reporting the results of additional site investigation, and describing the proposed program for further investigation and alternative source control measures.

CVR9/043

PLANT SITE AND OPERATIONS

Section 3
PLANT SITE AND OPERATIONS

SITE DESCRIPTION

The McCormick & Baxter Portland plant is on a site originally occupied by the Peninsula Lumber Mill, a sawmill operation. Located on the east bank of the Willamette River at approximately RM 7, the plant is in Township 1N, Range 1E, Section 17 of the USGS, Portland, Oregon, map, as shown in Figure 3-1. The plant site (about 58 acres) is bordered on the northwest by the Burlington Northern railroad, on the northeast by the Union Pacific railroad and a 100-foot bluff, on the southeast by Riedel International, and on the southwest by the Willamette River. The M&B site and adjoining properties up and downstream are zoned M-1--heavy industrial.

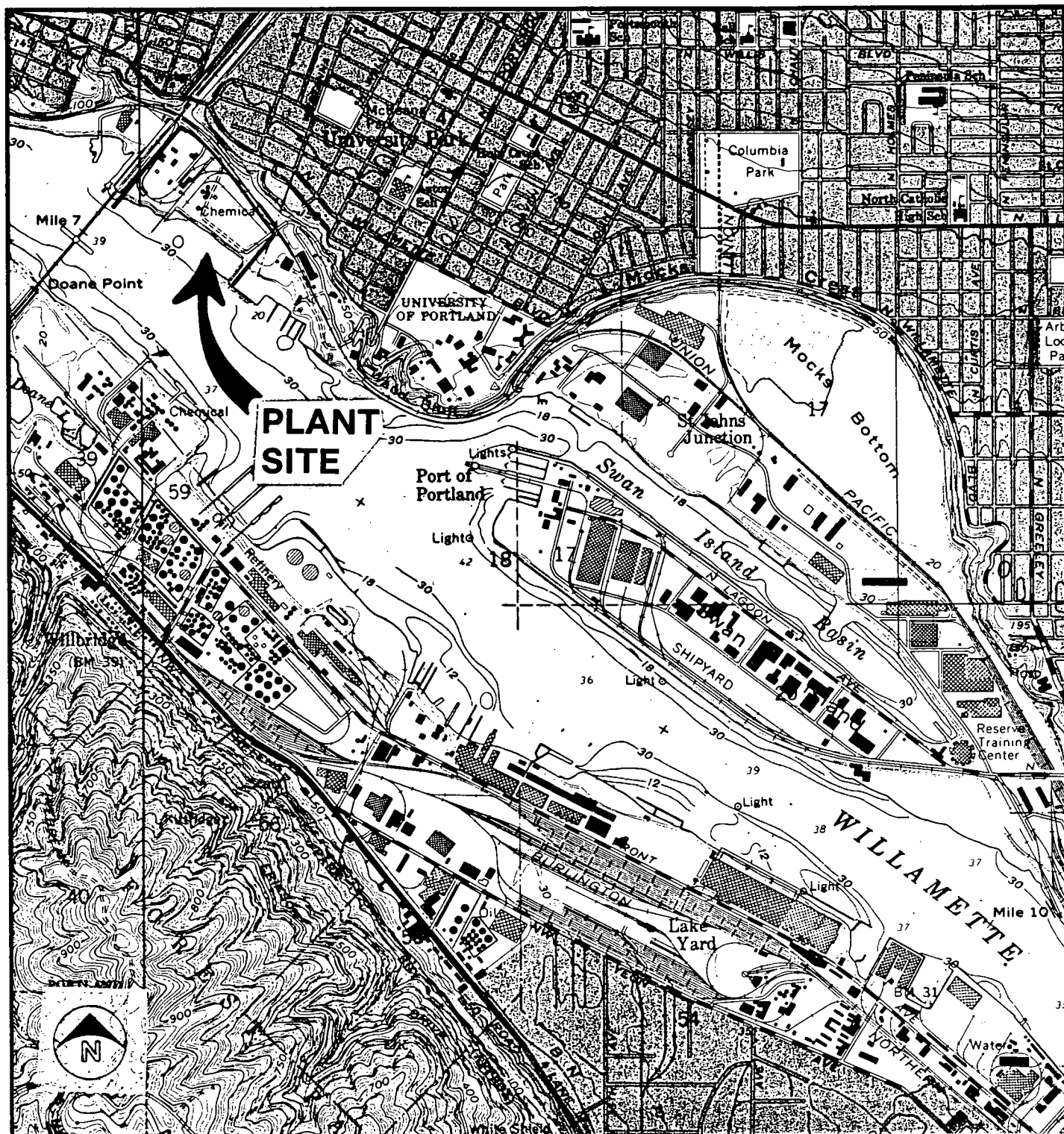
LOCAL GEOLOGY

The M&B plant is adjacent to the Willamette River on a man-made terrace composed of dredged medium to coarse grained sand. The dredge material, placed around 1912, is probably less than 20 feet thick at the site. It is underlain by alluvial sand and gravel containing scattered lenses of finer grained material. The alluvium is reported to reach a maximum thickness of 125 feet near the Columbia-Willamette confluence. Driller's logs for McCormick & Baxter's process water wells indicate a thickness of about 90 feet at the site.

At approximately 100 feet below the surface, the gravel becomes cemented. Cementation is locally characteristic of an older alluvial deposit known as the Troutdale Formation. The thickness and hydraulic continuity of the Troutdale Formation in the site vicinity is poorly defined because few wells have been drilled into it and none has penetrated through it. Drillers' logs of M&B's process water wells indicate that the Troutdale Formation extends to at least 220 feet below the site.

The Troutdale Formation is probably underlain by the Sandy River mudstone. This formation consists of inundated clay and silt, probably of lacustrine origin, and minor amounts of sand and gravel. It is estimated to be several hundred feet thick beneath the McCormick & Baxter plant site (Hogenson and Foxworthy, 1965).

Columbia River basalt probably lies underneath the Sandy River Mudstone at the site. This extensive volcanic deposit, estimated to range up to 1,000 feet thick in the east Portland area, is of undetermined thickness beneath the site. Its minimum thickness is probably no less than 120 feet (Hogenson and Foxworthy, 1965).



**FIGURE 3-1
VICINITY MAP**

**MCCORMICK & BAXTER
CREOSOTING COMPANY
PORTLAND, OREGON**

WATER USE

The plant uses domestic water from the City of Portland's Bull Run Reservoir, which supplies domestic water throughout the area. Records show the M&B plant is the only industry in the area to use groundwater for process purposes (the plant operates two onsite wells). Other industries in the area use river water for their cooling or other process needs.

Table 3-1 is a list of surface water and groundwater users from mile 8 of the Willamette River, approximately one-half mile upstream from McCormick & Baxter, to the Willamette-Columbia confluence. These users were identified in the files of the Oregon Water Resources Department. The table shows the first downstream irrigation use of water approximately 5 miles downstream from the site. The first recorded downstream withdrawals of groundwater or surface water for human consumption are 26 miles downstream for the cities of Columbia City and St. Helens.

In summary, recorded uses of groundwater and surface water in the vicinity of McCormick & Baxter are for industrial and irrigation purposes. The closest recorded downstream users of either surface water or groundwater for human consumption are cities located on the Columbia River more than 25 miles downstream from the site.

GROUNDWATER

Unconfined groundwater occurs in the unconsolidated alluvium, the partially indurated Troutdale Formation, and in the underlying Columbia River basalts. Confined groundwater is also reported in the Columbia River basalts, but its presence beneath the site is unknown.

Because of its generally fine-grained nature, the Sandy River mudstone is not considered a productive aquifer. However, wells completed in isolated sandy or gravelly zones may yield appreciable amounts of groundwater (Hogenson and Foxworthy, 1965).

Groundwater in the area is recharged by infiltration of precipitation and discharges principally by seepage to streams. The Willamette River channel is the primary groundwater discharge area in the site vicinity.

Groundwater at the site flows southwest toward the Willamette River. The horizontal hydraulic gradient is strongly influenced by river stage. During periods of high river stage, the gradient across the site decreases and minor bank storage may occur.

Table 3-1
WATER USE IN McCORMICK & BAXTER VICINITY

User Name	Location			River Mile	Distance ^a From M&B	Water Source	Use	Amount
	1/4	Section	Tier/Range					
Pennsylvania Salt Mfg. Co.	SW/NW	18	1N/1E	W8	0.5 Up	Willamette	Industrial	No Record
Fibreboard Paper Products Co.	NW/SW	18	1N/1E	W7.5	0	Willamette	Industrial	60 gpm
McCormick & Baxter	SW/SW	7	1N/1E	W7.5	0	Ground	Industrial	750 gpm
McCormick & Baxter	SW/SW	7	1N/1E	W7.5	0	Ground	Industrial	2.0 cfs
West Coast Adhesives	NE/NE	2	1N/1W	W4	3.5 Down	Willamette	Industrial	1.12 cfs
Alder Creek Lumber Co.	SW/SW	27	2N/1W	W3.5	4 Down	Multnomah Channel	Fire Fighting	0.5 cfs
Oregon Steel Mills	SE/NE	27	2N/1W	W2.5	5 Down	Willamette	Industrial	33 cfs
T.J. Gleie (Stanley G. Hoare)	SW/NE	27	2N/1W	W2.5	5 Down	Willamette	Irrigation	0.01 cfs
Pacific Coal Corp.	NE/SW	23	2N/1W	W1.5	6 Down	Willamette	Dust Control	2.67 cfs

^aMiles upstream or downstream from the site.

CVR32/038

PLANT AND PROCESS DESCRIPTION

M&B's treated wood products plant includes untreated log and pole storage; peeler (log debarker); untreated wood drying facilities (dry kiln and pole dryers); treating cylinders (retorts); treated product storage and shipping; fuel and wood preservative storage; boiler room; office; laboratory; and wood preservative recovery and wastewater treatment units. The location and identification of the major facilities at the treatment plant are shown in Figure 3-2.

The Portland plant originally started operation in the fall of 1945 with one retort (8' diameter x 144' long) treating timbers and poles with creosote and a mixture of creosote and petroleum. The creosote is a blend of several of the fractions produced during the distillation of coal tar. Creosote-treated wood products include poles, piling, construction material, and materials intended for marine exposure. The creosote is also mixed in varying proportions with petroleum (i.e., 50:50 and 30:70) to treat railroad crossties, switchties, and other construction timbers.

In 1951 a second retort was added. In 1953, the plant began using the wood preservative pentachlorophenol for treating poles, crossarms, and timbers. The pentachlorophenol is mixed with medium weight aromatic oil to form a treating solution of about 5.5 percent, by weight, pentachlorophenol and 94.5 percent medium weight aromatic oil. This treating solution is commonly referred to as "penta in oil."

In 1954 a third retort (8' diameter x 92' in length) was added for treating wood products with waterborne preservatives. Waterborne preservatives differ from creosote and penta in that they use water as a carrier as opposed to oil. Waterborne preservative solutions containing chrome were used up to 1970, at which time chrome was discontinued.

Since 1970 ammoniacal copper arsenate (ACA), a waterborne preservative, has been used. ACA, also referred to as chemonite, is an ammoniacal solution of copper and arsenic which forms an insoluble precipitate of copper arsenate in the wood on evaporation of aqua ammonia.

In 1968, the Cellon (penta in liquified petroleum gas) wood treating system with a fourth retort (8-foot-diameter by 144-foot length) was installed. Cellon is a wood preservative solution of pentachlorophenol, liquid butane, and isopropyl ether. The liquid butane carries the preservative into the wood and along with the isopropyl ether are solvents that dissolve the pentachlorophenol.

M&B uses three types of pressure processes in the application of wood preservatives to the wood. The type of treatment depends on the preservative to be used.

Creosote, creosote mixed with oil, and pentachlorophenol in oil treatment initially requires the wood to be seasoned. This seasoning step is commonly called Boultonizing. The wood is placed in the retort which is then filled with the oil-borne preservative and heated. A vacuum is applied which lowers the boiling points of the water in the wood, causing it to vaporize. The vapors are removed from the retort via a vacuum pump and condensed. The condensate is pumped to the oil/water separator to recover the oil-based preservative followed by wastewater treatment.

Once seasoned, the wood is either pressure-treated by the full-cell process or the empty-cell process. The full-cell process leaves the wood cells full of preservative while the empty-cell process coats the wood cell with preservative. In the full-cell process, the retort is filled with preservative and pressure and heat are applied so the preservative penetrates the wood. In the empty-cell process, the retort is pressurized with air before the addition of the preservative and heat. This pressure is maintained while the preservative is added. An equalizing tank is used to store the preservative for this process and the air in the retort is interchanged with the preservative in the storage tank.

At the end of the pressure-treating period, the pressure is released and the preservative is pumped back to the storage tank. As the pressure is released, the air trapped in the wood cells expands and forces the excess preservative out of the wood. Following the application of the preservative, the wood remains in the retort and is subjected to a cleanup cycle (expansion bath, intermediate vacuum, steaming, and final vacuum) to remove free oil from within the treated wood and excess preservative from the surface of the treated wood. The excess preservative removed from the treated wood is condensed and then pumped to the oil/water separators and wastewater treatment system.

Chemonite ammoniacal copper arsenate (ACA) waterborne treatment initially involves steam conditioning the wood inside the retort prior to applying ACA. Steam conditioning removes the excess moisture from the wood and softens the wood so as to make the wood more penetrable to the preservative. After the steaming cycle, a vacuum is applied, the moisture is condensed, and the water is pumped to the storage tanks.

After the wood is seasoned, the retort is filled with ACA and pressure and heat are applied so the preservative penetrates the wood. At the end of the pressure-treating period, the pressure is released and the preservative is pumped back

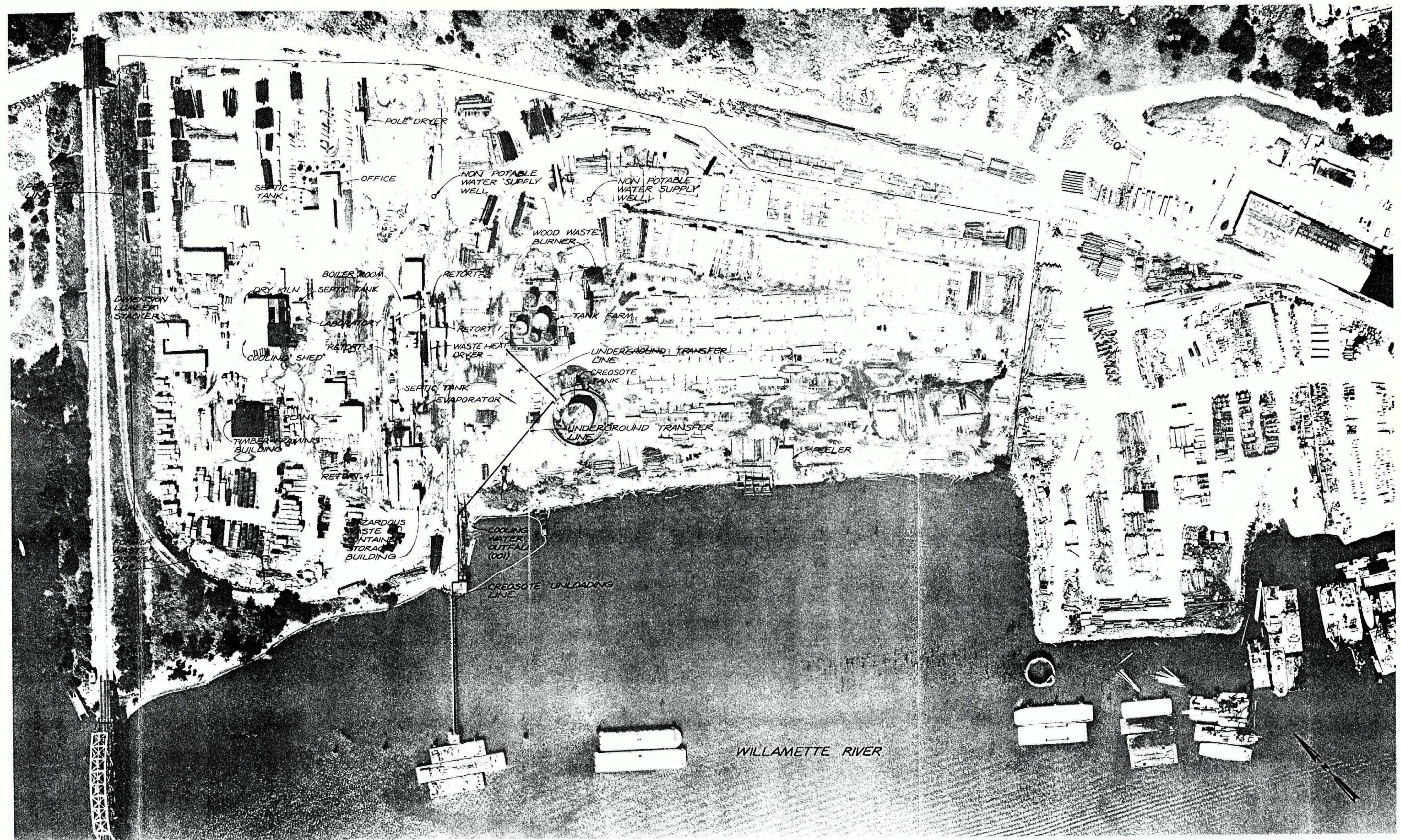


FIGURE 3-2
 SITE PLAN
 McCORMICK & BAXTER
 CREOSOTING COMPANY
 PORTLAND, OREGON

to the storage tank. Following the removal of the preservative, the wood remains in the retort and is subjected to a cleanup cycle (vacuum and steaming) to remove excess preservative from within and on the surface of the treated wood. The number of these steps depends on the application of the treated wood product.

Cellon (penta in liquified petroleum gas) treatment initially involves placing the wood in the retort and purging the retort with an inert gas. After purging, the retort is filled with the Cellon solution and heat and pressure are applied so the preservative will penetrate the wood. Following the pressure-treating period, the vapors inside the retort are recovered and pumped to the preservative work tank. After the preservative has been removed, a vacuum is applied to remove excess preservative from within and on the surface of the wood. In addition, the treated wood undergoes a final cleanup cycle where the wood is immersed in an oil bath inside the retort to remove penta crystals on the surface of the wood. After immersion, the oil is recovered and pumped to the storage tanks, then a final vacuum is applied to remove excess oil.

WASTE MANAGEMENT

Waste generated at the plant by the pressurized treatment of wood products with preservatives consists of steam condensate, water and oil containing preservatives, and residues resulting from the cleanout of the retorts, oil recovery system, storage tanks and wastewater treatment systems. The residues are primarily wood fiber, dirt, and grit coated with oil-containing preservatives.

M&B has stayed current with technological developments in the industry and has been sensitive to the environmental issues concerning industrial waste management. As a result, M&B waste management practices have been in line with the standards of the time and, in some cases, they have been the state of the art. A brief chronological summary of M&B waste management practices and process improvements is as follows:

- o Between 1945 and 1969, the plant's wastewater from the retorts' oil/water separators, along with the boiler blowdown and condenser cooling water were directly discharged to the Willamette River.
- o In 1968 discontinued offsite disposal of residues from the retorts, oil/water separators, and evaporator.
- o Between 1968 and 1971, residues from the retorts, oil/water separators, and evaporator were disposed of in the old waste disposal area.

- o In 1969, M&B installed an evaporator to dispose of excess process wastewater. The installation of the evaporator allowed M&B to stop discharging wastewater from the oil/water separators to the Willamette River. Non-process wastewater (condenser cooling water) continues to be discharged to the Willamette River. This discharge is permitted under M&B's National Pollution Discharge Elimination System (NPDES) wastewater discharge permit originally issued by DEQ in 1969. The boiler blowdown was routed to an onsite area (the old waste disposal area) located at the northwest corner of M&B property. This water did not contain organic preservatives; however, it may have contained other chemicals (i.e., chromate, phosphates) that were used as boiler water conditioning additives.
- o In 1970 M&B received an Industrial Water Pollution Award from the Pacific Northwest Pollution Control Association for the development, installation, and operation of the evaporator. The evaporator represented best available technology, as determined by the EPA. This made possible zero-discharge of process water.
- o Between 1968 and 1983, M&B washed the Cellon-treated wood with a caustic solution to remove surface penta crystals.
- o In 1969, M&B began using a lumber kiln for drying poles. This reduced the amount of steam condensate and wastewater from the retorts that required treatment and evaporation.
- o In 1970, M&B rerouted the boiler blowdown to the evaporator.
- o In 1971, M&B increased the capacity of the oil/water separators to increase the recovery of oil preservatives, which resulted in less residue accumulating in the evaporator.
- o In 1972, M&B installed a pole/piling dry kiln. This conversion further reduced the amount of steam condensate and wastewater from the retorts that required treatment and evaporation.
- o In 1972, M&B began storing wood preservative sludges in metal containers; and discontinued the onsite disposal of wood preservative residues.
- o In 1974, M&B began using a stability compound that reduced the carbonization of penta treating solutions. Use of this compound significantly decreased residue accumulation and produced a cleaner treated wood product.

- o In 1978, M&B began transporting the wood preservative residues that had accumulated from 1972-1978 in metal containers to the Chem Security System, Inc., hazardous waste management facility located near Arlington, Oregon.
- o In 1980, the Chemonite treating facilities were isolated from the oil preservative facilities. Process wastewater, that formerly went to the oil/water separators and the evaporator, was now recycled for use as makeup water for the wood preservative solutions. Concrete and asphaltic pavement and containment structures were constructed around the facilities to prevent spills on the ground.
- o In 1981, M&B built a secured hazardous waste drum facility and implemented the hazardous waste manifest system per EPA-DOT regulations.
- o In 1983, M&B changed the treatment cycle for the Chemonite process, using a higher percentage of ammonia in solution and prolonged vacuum and steaming periods to reduce the formation of surface deposits on the treated wood.
- o In 1983, a 42,000-gallon above-ground steel tank was designated for emergency storage of excess process wastewater from the oil/water separators. As capacity becomes available, the excess process wastewater is pumped to the evaporator.
- o In 1983, M&B installed a nitrogen blanketed oil bath waste system for the Cellon treatment system. The Cellon treated wood is washed with an oil bath inside the retort to remove penta crystals. This system eliminated the practice of washing the Cellon treated wood with caustic.
- o In 1983, M&B installed a waste heat (from the boiler) pole dryer, which further reduced the amount of steam condensate and wastewater from the retorts that required treatment and evaporation.

RECENT INSPECTIONS AND MAINTENANCE

McCormick & Baxter has implemented a site environmental improvement program to further minimize the potential offsite releases of wood preservatives to the environment. This program includes daily inspections and scheduled maintenance of wood preservative process and storage equipment, weekly plant environmental meetings; cleaning, internal inspection and repair of wood preservative storage tanks; cleaning,

inspection, and repair of pumps, pipes, and valves; concrete sumps and containment structures; and general site cleanup. These efforts, along with the process and waste management changes previously described, are part of a continuous program to upgrade plant operations.

Specific items that have been completed include:

- o The inside of tank Nos. 2 and 6 were cleaned to the bare metal. Visual external and internal inspection, along with ultrasonic thickness measurements, were made. The floor and walls were found to be in good condition with no sign of leaks, cracks, or holes. The weld holding tank No. 6 bottom to the shell was pitted in several locations and required patch welding. The tank bottom was pitted in only a few places and these pits were also repaired by welding.
- o The inside of the wastewater evaporator was cleaned to bare metal. Above surface external and internal inspections showed the evaporator floor and walls to be in good condition with no signs of cracks, holes, or pitting.
- o The insides of the oil/water separators were cleaned to bare metal. The floor and bottom portion of the walls of the oil/water separators were pitted but there were no signs of cracks or leaks. To extend the life of the separators, additional 5/16-inch-thick steel plate was welded over the present floor and from the floor to 14 inches up on the exterior walls. All internal surfaces were coated with a coal tar epoxy.
- o The pipeline and hose from the marine terminal to the creosote storage tank has been periodically hydrostatically tested to comply with U.S. Coast Guard regulations.

CVR9/042

PRELIMINARY INVESTIGATION

Section 4 PRELIMINARY INVESTIGATION

McCormick & Baxter initiated an investigation of their plant site in August 1983 when they hired Aqua Resources Inc. to assess the potential for offsite environmental impacts resulting from releases of plant wastes. For this assessment, Aqua Resources constructed four boreholes/groundwater monitoring wells to investigate the subsurface soil and water conditions at the plant site. Test data (reported in detail later in this section) indicated some wood preservative residues could be migrating offsite.

McCormick & Baxter then hired CH2M HILL in December 1983 to review these findings and to continue the environmental site investigation. Since then, CH2M HILL's investigation has addressed past and present plant practices that were or are common in the industry. The investigation has included the following items:

- o Review of M&B Portland plant's files and plant site photographs depicting the changes at the plant and surrounding area over the last 40 years.
- o Review of DEQ's files on the environmental history of M&B.
- o Visual inspection of the plant site.
- o Collection and analysis of groundwater samples from the four existing monitoring wells.
- o Soil sample collection and analysis at various depths from 13 additional soil boring locations.
- o Installation of nine additional groundwater monitoring wells.
- o Collection and analysis of groundwater samples from the nine new monitoring wells.
- o Collection and analysis of four surface soil samples along the bank of the Willamette River.
- o Collection and analysis of process water supplied from onsite water supply wells.
- o Analysis of weekly grab samples of surface water runoff from the site on a monthly basis.
- o Continuous measurement and recording of the flow of surface water runoff from the site.

SAMPLING AND TESTING PROCEDURES AND RESULTS

SOIL BORING

The locations of the four soil borings/groundwater monitoring wells (MW-A, MW-B, MW-C, MW-D) Aqua Resources constructed in September 1983 are shown in Figure 4-1. Monitoring Well-A (MW-A) is located at the north end of the site, believed to be upgradient and, therefore, representative of background site conditions. Monitoring Well-B (MW-B) is located at the southeast corner of the site upriver and away from any of the process and chemical storage areas. It was also believed to be representative of background site conditions. Monitoring Well-C (MW-C) is located in the process area adjacent to the tie plant, and about halfway between MW-A and the Willamette River. It was believed to be representative of typical conditions within the process area. Monitoring Well-D (MW-D) is located in the northwest corner of the site, believed to be downgradient from the old waste disposal area.

In July 1984, CH2M HILL constructed seven more soil borings/groundwater monitoring wells to provide a more detailed characterization of the site. These well locations are also shown in Figure 4-1.

Monitoring Wells-E, -F, and -G (MW-E, MW-F, MW-G) are located in the northwest corner of the site. MW-E is in the former waste disposal site, MW-F is between the river and the waste disposal area and slightly downstream, and MW-G is between MW-D and the river--downstream from MW-F. Wells-E, -F, and -G were intended to gather more information on the migration of the wood preservative constituents from the former waste disposal area.

Monitoring Wells-H, -I, -J, and -K (MW-H, MW-I, MW-J, and MW-K) were proposed to assess the presence of wood preservatives in the soil and groundwater resulting from specific plant operations (i.e., storage tanks, retorts, discontinued cellon wash, and treated pole storage). MW-H is located in the process area adjacent to retort No. 1. MW-I is located next to the west wall of the tank farm. MW-J is located in the former Cellon wash area, and about halfway between the boiler room and the laboratory. MW-K is located in the northeast corner of the site in the treated pole storage area.

In October 1984, two more soil borings/groundwater monitoring wells (MW-L and MW-M) were constructed along with four more soil borings (BH-1, BH-2, BH-3, and BH-4). These additional soil borings and monitoring wells were constructed to further investigate the presence of wood preservative constituents associated with the tank farm. Monitoring Wells-L and -M (MW-L, and MW-M) were located next to the river. MW-M is

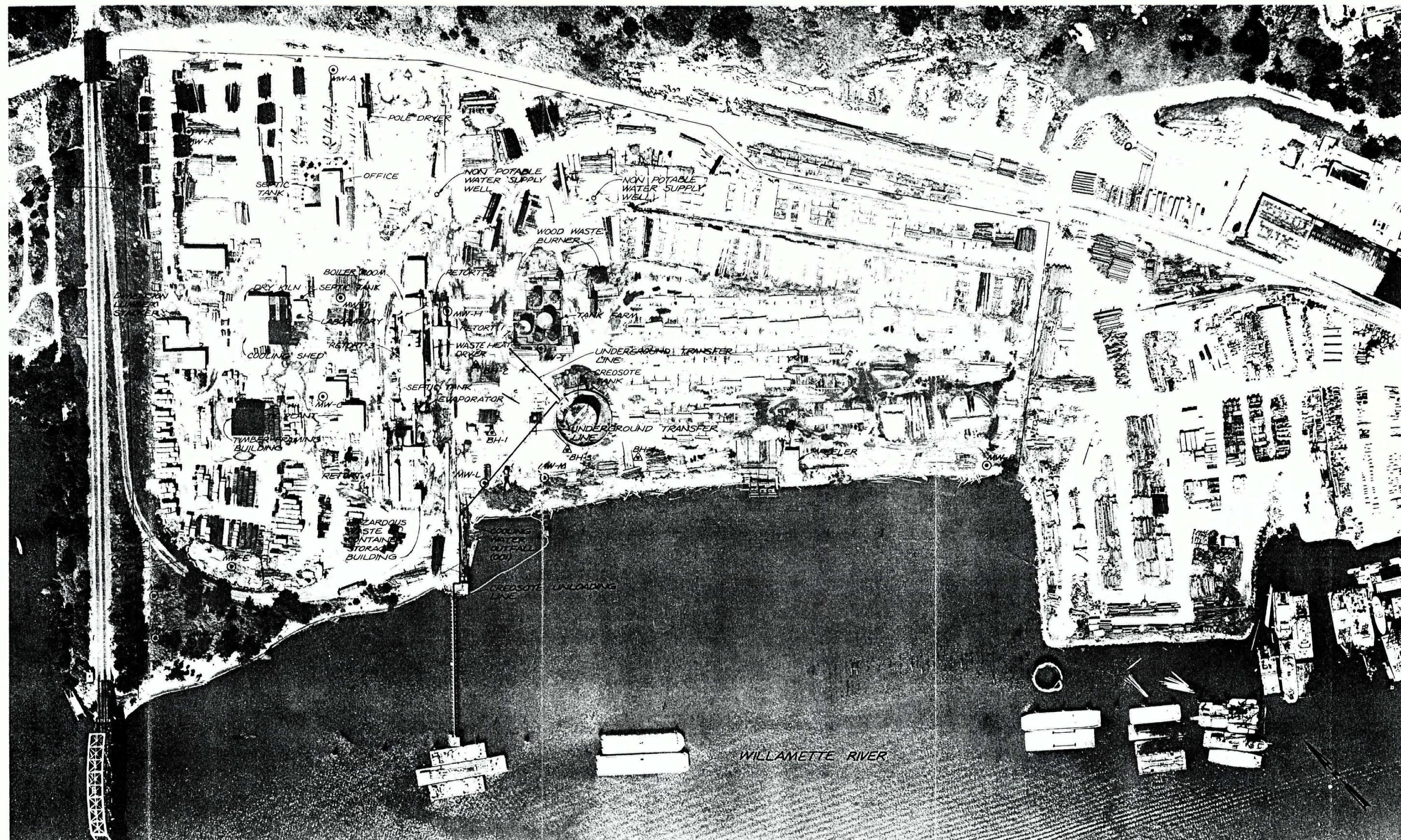


FIGURE 4-1
MONITORING WELL & BORING HOLE LOCATIONS
McCORMICK & BAXTER
CREOSOTING COMPANY
PORTLAND, OREGON

about 300 feet from the tank farm. MW-L is about 100 feet downriver from MW-M. The first soil boring (BH-1) is about halfway between BH-2 and MW-L. The second soil boring (BH-2) is about halfway between MW-I and the waste heat dryer. The third soil boring (BH-3) is next to the large creosote tank on the side nearest MW-M, and the fourth soil boring (BH-4) is about 150 feet upriver from BH-3.

SOIL BORING/MONITORING WELL CONSTRUCTION

All soil borings were drilled by Geo-Tech Explorations of Beaverton, Oregon, with a 3-3/4-inch (ID) hollow-stem auger. Samples were collected with a standard split spoon at about 5-foot intervals. The bottom of each shallow boring was established in the field when wood preservative constituent levels were low or absent based on odor and visual appearance. The borings completed as monitoring wells were terminated at depths that would allow water samples to be collected from specific saturated intervals.

Borings not completed as monitoring wells were sealed by pumping a bentonite slurry through a drop pipe extending to the bottom of the auger. Bentonite slurry was added as the auger was withdrawn in 5-foot sections and the boreholes were topped off with bentonite after removing the bottom auger.

Each borehole was logged under the direct supervision of a qualified geologist or hydrogeologist. The geologic log and construction details for these wells are provided in Appendix B.

SOIL SAMPLING PROCEDURE

Field decontamination procedures for all sampling and drilling equipment were followed to minimize the probability of cross contamination. Drilling equipment was steam cleaned between borings, and soil sampling equipment was decontaminated by a detergent wash, double tapwater rinse, methanol rinse, toluene rinse, acetone rinse and, distilled water.

Soil samples were collected in 8-ounce, wide-mouth soil sample jars with teflon-lined lids. The jars were labeled immediately before sampling with the date, the time, and a four-part sample number that indicated the location and depth of each sample. After sampling, the jars were temporarily stored in insulated covered coolers and then transferred to a freezer for storage or analysis.

Samples destined for laboratory analysis were shipped via overnight commercial carrier to CH2M HILL's environmental laboratory in Corvallis, Oregon. Chain-of-custody

documentation included custody tape on jars and coolers and chain-of-custody forms accompanying shipped samples.

ANALYSES OF SOIL SAMPLES

The field sample description provided a basis for selecting samples to be sent to the laboratory for chemical testing. A minimum of three samples were chosen for laboratory analysis from each boring using the following plan:

- o One sample from the unsaturated zone was analyzed to characterize soils above the water table.
- o One sample from the saturated zone was analyzed to characterize soils below the water table.
- o One sample, usually from the saturated zone, to provide a more detailed chemical characterization of soils encountered in the boring.

Samples selected for laboratory analysis included samples in which wood preservative constituents were most apparent visually and by odor. Other criteria used to select samples for laboratory analysis included choosing a sample adjacent to the water table to test for the presence of floating oil, and choosing a sample from near the bottom of the borehole to document the probable lower extent of any wood preservative constituents.

To provide consistency in the data base being developed, the test parameters and analytical techniques previously used in other site investigation programs were followed. Testing and analytical procedures conformed to accepted EPA and DEQ procedures, and visual or odor categorization was performed on all soil samples.

LABORATORY RESULTS OF SOIL SAMPLES

Normal native soil total copper (Cu) concentrations range from 2 to 100 mg/kg and average 30 mg/kg, according to Bowen (1966). Soil samples from borings for MW-A and -B, which should be representative of background levels for the site, showed total copper concentrations range from 1.5 to 24 mg/kg. The only soil samples having concentrations greater than 24 mg/kg were MW-E and -F (in the old waste disposal area) and MW-I (tank farm). The highest concentration from these borings was 30.5 mg/kg, which is still within the normal range for native soils.

Normal native soil total chromium (Cr) concentrations range from one to 1,000 mg/kg with an average concentration of 100 mg/kg, according to Bowen (1966). Soil samples from borings for MW-A and -B showed total Cr concentrations range

from 1.9 to 17.9 mg/kg. Soil samples having concentrations greater than 24 mg/kg were in borings for MW-D, -E, and -G (old waste disposal area) and MW-I (tank farm). The highest concentration from these borings was 36 mg/kg, which is below the reported average concentration in native soils.

Normal native soil total arsenic (As) concentrations range from one to 50 mg/kg, though it does not generally exceed 10 mg/kg (Bowen 1966). Soil samples from borings for MW-A and -B showed total As concentrations less than 13 mg/kg. Soil samples having concentrations greater than 13 mg/kg were in borings for MW-D and -E (in the old waste disposal area), MW-H (next to No. 1 retort), MW-I (tank farm), and MW-J (in the old Cellon wash area). The highest concentration from these borings was 27.9 mg/kg, which is still within the normal range for native soils.

Soil samples from borings for MW-A and -B showed oil and grease concentrations less than 1,000 mg/kg, PAH's less than 5 mg/kg, and PCP less than one mg/kg, which should indicate the background conditions for the site.

Soil samples from MW-C (process area) were equal to or less than the background levels found in MW-A and -B for oil and grease and PAH's. The highest concentration of PCP (1.4 mg/kg) was found at a depth of approximately 5 feet.

MW-D, -E, and -G (old waste disposal area) soil analyses all had concentrations of one or more of these three parameters that exceeded site background levels. Soil analysis of samples from MW-F, located less than 100 feet upriver from MW-G, showed concentrations of oil and grease, PAH's and PCP equal to or less than background levels found in MW-A and -B. The highest oil and grease concentrations found in the soils analyzed for MW-D, -E, and -G borings was 21,000 mg/kg at MW-E at a depth between 5 and 10 feet. The highest PAH analyzed was 250 mg/kg at MW-D at a depth around 30 feet. The highest PCP analyzed was 10,000 mg/kg, also at MW-D, at a depth around 30 feet.

MW-H (retort No. 1) soils analysis for PAH's and PCP were all equal to or less than background levels. The highest oil and grease concentrations analyzed were 10,000 mg/kg at a maximum depth between 20 and 25 feet.

Tank farm soil samples (MW-I, -M, and BH-1, -2 and -3) soil analyses all had concentrations of one or more of the three parameters that exceeded site background levels. Soil analysis of samples from MW-L, located less than 150 feet downriver from MW-M, showed concentrations of oil and grease and PAH's less than background and less than one mg/kg of PCP. The highest oil and grease concentration analyzed in the soils for MW-I, -M, and BH-1, -2, and -3 was at BH-1

(7,930 mg/kg) at a depth between 49 and 50.5 feet. The highest PAH concentration analyzed in the soil was 6,722 mg/kg at a depth between 35 and 36.5 feet at BH-3. The highest concentration of PCP analyzed in the soil was 136 mg/kg between a depth of 35 and 36.5 feet at MW-M.

MW-J (former Cellon wash area) soils analysis for PAH's were equal to or less than background levels; however, this is based on only one analysis at a depth between 30 and 35 feet; additional analysis at other depths should be performed to confirm this result. The highest oil and grease (1,150 mg/kg) and PCP (1,330 mg/kg) concentrations found in the soil samples analyzed were at a depth between 5 and 10 feet.

MW-K (treated pole storage) soil analysis for oil and grease and PAH's were all equal to or below background. All soil samples analyzed for PCP were below one mg/kg.

Summaries of the individual laboratory analyses of soil samples are provided in Appendix C.

GROUNDWATER MONITORING

The groundwater monitoring network at the M&B plant consists of 13 monitoring wells (see Figure 4-1). The screened interval of each monitoring well is listed in Table 4-1.

Table 4-1
MONITORING WELL SCREENED INTERVAL

Monitoring Well	Screen Elevation (feet above MSL)	
	Top	Bottom
A	13	6
B	12	7
C	15	10
D	8	3
E	18	-2
F	15.5	-4.5
G	15	-5
H	20.5	0.5
I	19.5	-0.5
J	21.5	1.5
K	22	2
L	17	-13
M	9.5	-20.5

Groundwater Levels

Water levels in monitoring wells and in the Willamette River have been measured weekly since April 1984. Water level measurements on selected dates are listed in Table 4-2. Measurements indicate that groundwater flows toward the river except during periods of high river stage, when the river loses water to bank storage. Figure 4-2 is a groundwater elevation map illustrating the configuration of the water table at the site on August 29, 1984. The gradient, or slope of the water table has ranged from a high of 0.008 feet/foot in July to a low of 0.003 feet/foot in December. The elevation of the water surface in MW-C was not included in Figure 4-2 because it was inexplicably high.

Table 4-2
WATER LEVEL DATA FOR SELECTED DATES

<u>Monitoring Well</u>	<u>7/25/84</u>	<u>10/3/84</u>	<u>12/13/84</u>
A	15.13	13.68	12.81 ²
B	8.89	7.84	10.25
C	20.36	20.13	20.92
D	8.47	7.48	10.78
E	8.96	7.22	11.15
F	7.10	6.88	9.69
G	NM ²	7.00	10.00
H	13.20	10.79	11.43
I	14.06	9.98	11.18
J	12.58 ³	10.40	11.73
K	NA ³	10.24 ³	10.66 ³
L	NA ³	NA ³	9.43
M ₁	4.60	NA ³	10.48
WR ¹		6.40	10.55

¹Water level in Willamette River. Stilling well located on McCormick and Baxter's dock.

²NM = not measured.

³NA = not applicable--well not yet installed.

Hydraulic Conductivity Testing

Hydraulic conductivity, or permeability, is a measure of the ease with which water moves through a porous medium. In an effort to measure permeabilities at the site, slug-withdrawal tests were conducted on MW-K and J. Approximately

0.41 gallon was withdrawn instantaneously from each well and the water level measured within 35 to 55 seconds immediately thereafter. No drawdown was measured in either well. Based on this result, a lower limit of hydraulic conductivity was estimated using a method described by Ferris and Knowles (1963). The resultant value of hydraulic conductivity, 80 feet/day (2.8×10^{-2} cm/sec), is reasonable for the fine to coarse grained sands that occur at the site.

It should be cautioned that slug tests give reliable results only for the aquifer materials immediately surrounding the test well. The results may not necessarily be representative of the bulk aquifer properties.

Rate of Groundwater Movement

The rate of groundwater movement at the site may be estimated using a modified form of Darcy's Law, expressed as follows:

$$V = KI/n$$

where

V = average linear velocity (ft/day)

K = hydraulic conductivity (ft/day)

I = hydraulic gradient (ft/ft)

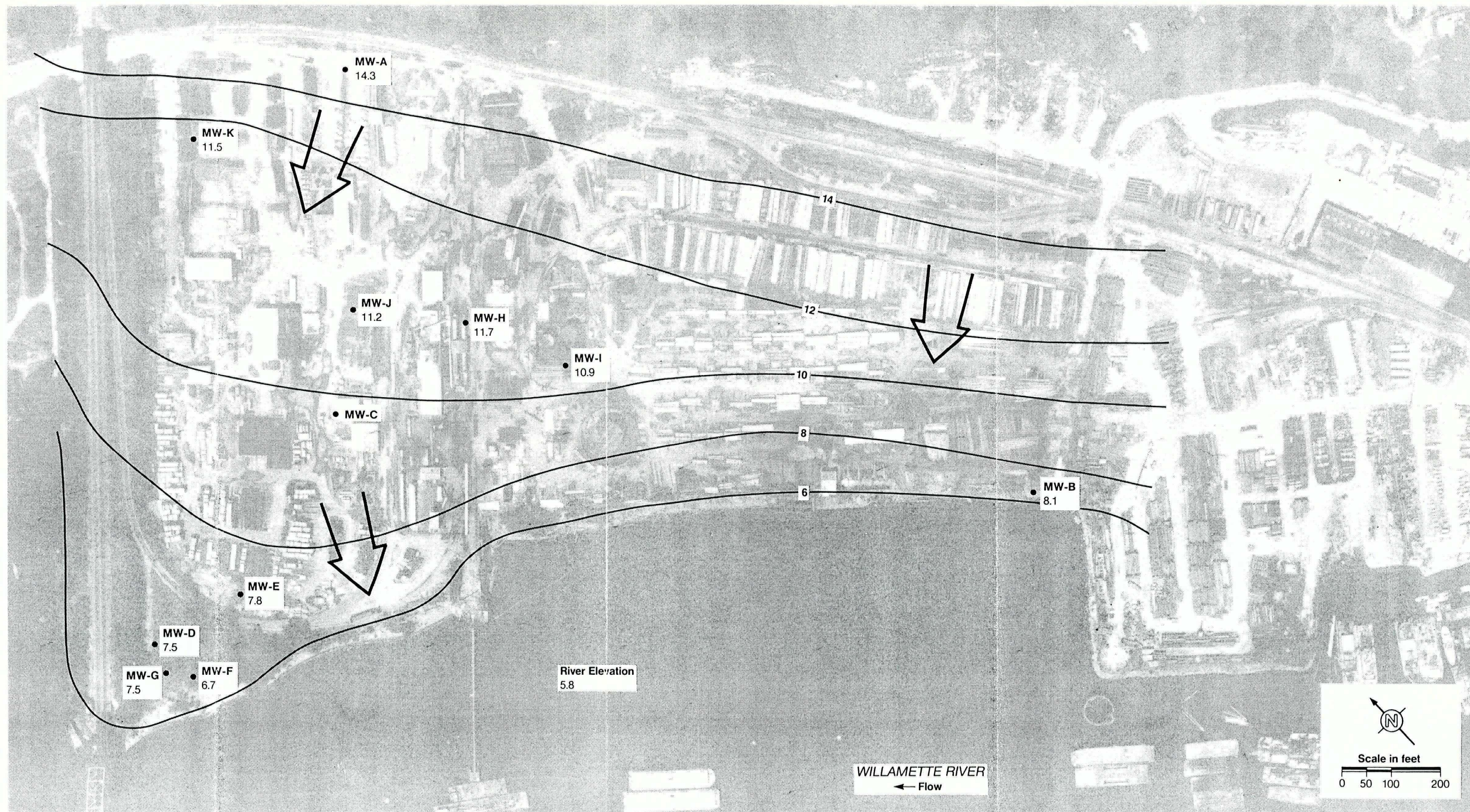
n = effective porosity (dimensionless)

The hydraulic gradient has been estimated as 0.008 during low river stage, 0.003 at high river stage. The hydraulic conductivity estimated by slug tests is 80 ft/day. An effective porosity of 0.10 to 0.20 is consistent with the sediments encountered at the site. Using the given equation, the rate of groundwater movement is estimated to range from 2.4 to 1.2 feet/day during high river stage, and 6.4 to 3.2 feet/day during low river stage.

Groundwater Quality

Monitoring wells A through D have been sampled periodically since September 1983. Monitoring wells E through K have been sampled twice since July 1984. Monitoring wells L and M have been sampled once since October 1984. All sample results are provided in Appendix C.

Because groundwater flows toward the river, MW-A and B serve as background monitoring wells. The levels of copper, total chromium, and arsenic in MW-A and B are relatively high for background, yet are probably not a result of M&B's operations. Based on the soil analyses discussed earlier in this report,



Explanation

- 11.7 Elevations in feet above MSL
- 2-foot Contour Interval
- Groundwater flow direction

FIGURE 4-2
GROUNDWATER CONTOUR MAP
AUGUST 29, 1984
MCCORMICK & BAXTER
CREOSOTING COMPANY
PORTLAND, OREGON

we believe these are representative background levels. This conclusion is based on the following information:

- o Both wells are located in areas of no known chemical storage, processing, or application; storage of treated poles; or disposal of wastewater or waste materials.
- o Neither well had significant levels of oil and grease, PAH's, or pentachlorophenol, which are normally associated with a wood-preserving plant.
- o The soil analyses with depth for both wells showed fairly homogeneous levels of copper, chromium, and arsenic; insignificant levels of oil and grease; and no detectable PAH's or pentachlorophenol. The uniformity of the concentration of the individual parameters with depth is inconsistent with a surface source.

The distribution of pentachlorophenol and total organic carbon in the onsite groundwater is illustrated in Figure 4-3 (Sheet 1). The map shows that organics, particularly pentachlorophenol, are concentrated in three areas: down-gradient of the former waste disposal area (MW-D, -E, -F, and -G); downgradient from the tank farm (MW-I, -L, and -M); and, to a lesser extent, in the vicinity of the former Cellon wash area (MW-J).

Figure 4-3 (Sheet 2) shows the distribution of copper, total chromium, and total dissolved solids in onsite groundwater. The distribution of heavy metals is similar to that of pentachlorophenol. Concentrations of copper and total chromium in MW-A, one of the upgradient background wells, suggest that the background concentration of metals in the area may be relatively high. The former Cellon wash area is apparently the source of the high dissolved solids concentrations measured in MW-J. At a pH of 5.5 in September 1984, MW-J also exhibited the lowest pH of any monitoring well.

STORMWATER OUTFALL

The water quality of the stormwater outfall will continue to be measured weekly. The flow is being continuously monitored and will be estimated on a daily basis. Grab samples are obtained weekly and shipped to CH2M HILL's Corvallis laboratory for analysis. Laboratory analyses for each include copper, total chromium, hexavalent chrome, arsenic, oil and grease, pH, TDS, pentachlorophenol, and PAH's. This 9-month investigation is scheduled to be completed at the end of June 1985.

OFFSITE SAMPLING

The DEQ has been concerned with the potential offsite migration of wood preservative constituents and their impact on the Willamette River. Periodic sampling of the Willamette River, which included gathering samples of river water and sediments near McCormick & Baxter, has been conducted by the DEQ. Samples were collected in August 1983, October 1983, and July 1984 and were analyzed for PAHs, pentachlorophenol, and other preservatives. Although no pentachlorophenol was detected in the sediments, analysis revealed low levels of some PAHs. PAHs, PCP, and other preservatives were not detected in any of the water samples.

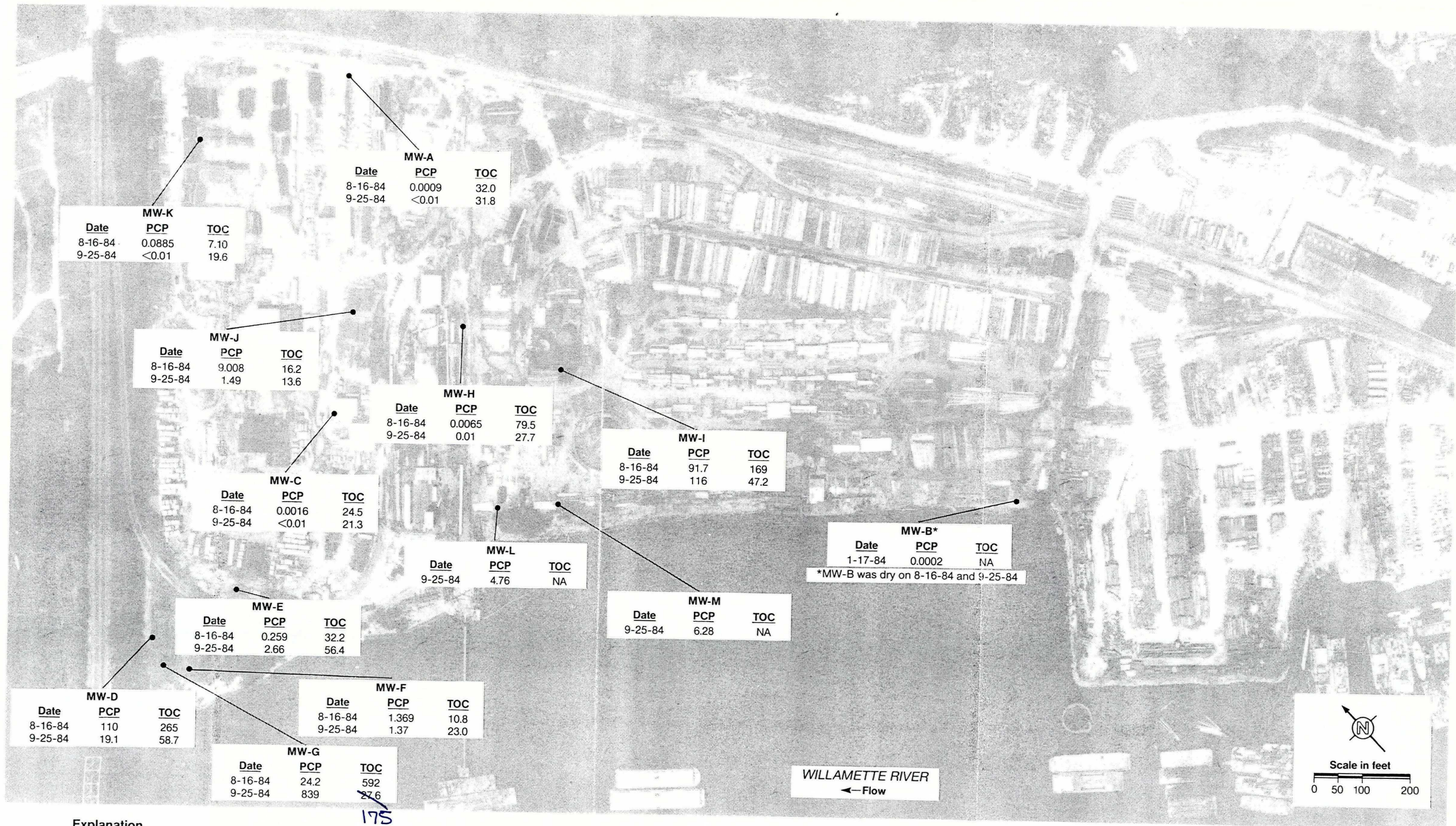
SITE CHARACTERIZATION

Initial groundwater, surface, and soil sample analyses along with information regarding past and present plant activities provide sufficient information to form a preliminary characterization of the site. Soil and water samples have been analyzed for oil and grease, PCP, PAH's, TOC, copper, chromium, and arsenic. The initial sample analyses suggest that the wood preservatives present in the pressure treatment process area and the treated pole storage area is confined to the surface soils. The preliminary characterization shows that, for most of the site, wood preservatives in the groundwater and subsurface soils are primarily the result of past operating practices.

The following briefly describes the site's potential significant sources of offsite releases of wood preservatives. Remedial actions for mitigation of the potential long-term effects of such releases will be developed and evaluated in the remedial investigation and feasibility study described in Section 5.

o Former Cellon Wash Area

The former Cellon wash area occupies an area roughly 200 feet by 50 feet between the laboratory and the boiler room. Monitoring Well-J is centrally located in the area and is easily accessible in the open space. Samples taken from MW-J indicate that although penta was detected in the groundwater, the wood preservatives in this area are mainly associated with the soil. Higher concentrations appear at the surface, and rapidly decrease with depth. The presence of wood preservatives in this area was apparently caused solely by past practices. This area is now used for treated wood product storage and no longer is used for washing treated material.

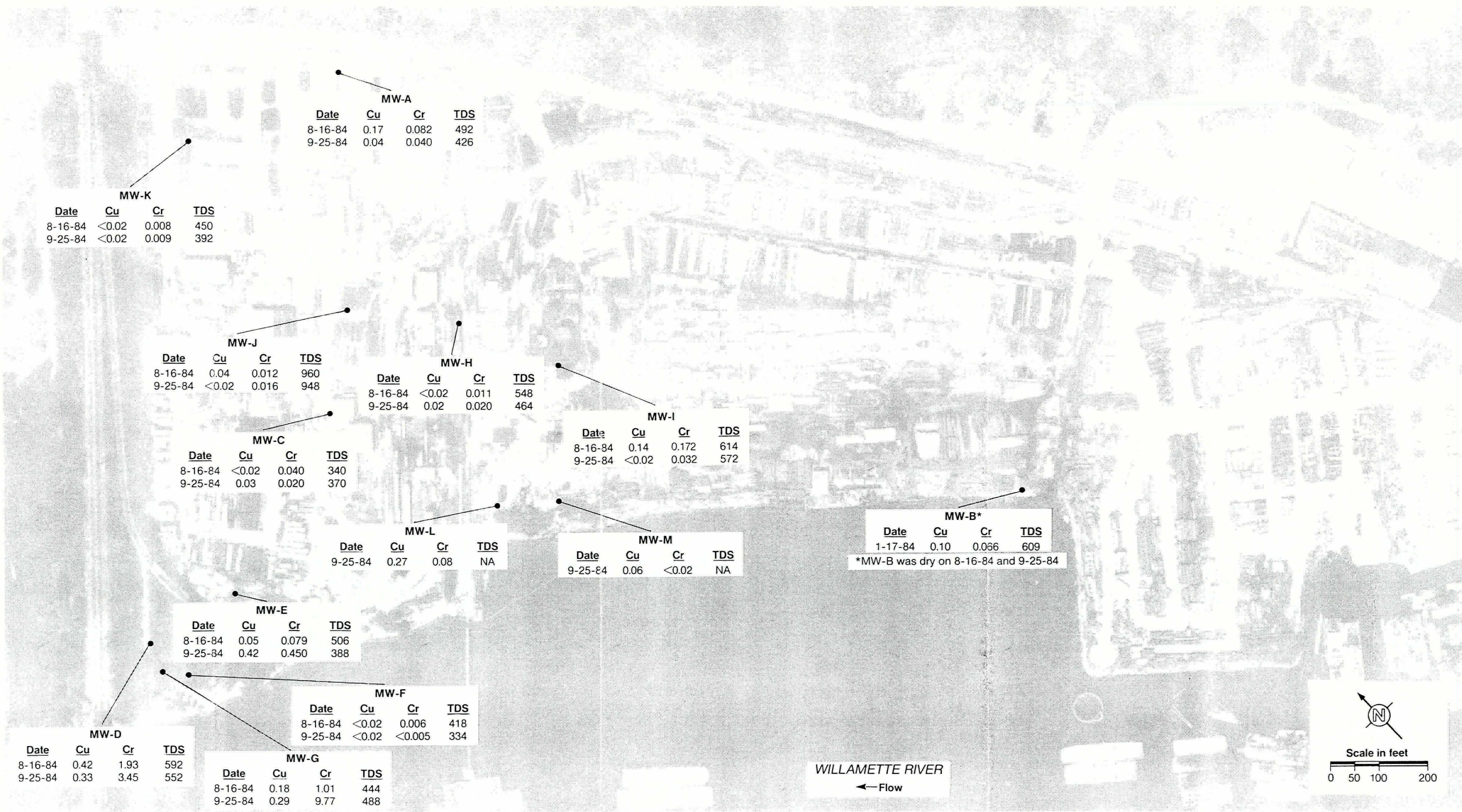


Explanation

- Monitoring Well
 - PCP Pentachlorophenol
 - TOC Total Organic Carbon
 - NA Not Analyzed
- All concentrations in mg/l

NOTE:
THE DATA INDICATES ABSOLUTE LEVELS OF INDIVIDUAL PARAMETERS AT SPECIFIC ONSITE LOCATIONS. EXPOSURE CALCULATIONS ARE REQUIRED TO ESTIMATE POTENTIAL OFFSITE LEVELS.

FIGURE 4-3 (Sheet 1)
GROUNDWATER QUALITY MAP
McCORMICK & BAXTER
CREOSOTING COMPANY
PORTLAND, OREGON



MW-A

Date	Cu	Cr	TDS
8-16-84	0.17	0.082	492
9-25-84	0.04	0.040	426

MW-K

Date	Cu	Cr	TDS
8-16-84	<0.02	0.008	450
9-25-84	<0.02	0.009	392

MW-J

Date	Cu	Cr	TDS
8-16-84	0.04	0.012	960
9-25-84	<0.02	0.016	948

MW-H

Date	Cu	Cr	TDS
8-16-84	<0.02	0.011	548
9-25-84	0.02	0.020	464

MW-C

Date	Cu	Cr	TDS
8-16-84	<0.02	0.040	340
9-25-84	0.03	0.020	370

MW-I

Date	Cu	Cr	TDS
8-16-84	0.14	0.172	614
9-25-84	<0.02	0.032	572

MW-L

Date	Cu	Cr	TDS
9-25-84	0.27	0.08	NA

MW-M

Date	Cu	Cr	TDS
9-25-84	0.06	<0.02	NA

MW-B*

Date	Cu	Cr	TDS
1-17-84	0.10	0.066	609

*MW-B was dry on 8-16-84 and 9-25-84

MW-E

Date	Cu	Cr	TDS
8-16-84	0.05	0.079	506
9-25-84	0.42	0.450	388

MW-F

Date	Cu	Cr	TDS
8-16-84	<0.02	0.006	418
9-25-84	<0.02	<0.005	334

MW-D

Date	Cu	Cr	TDS
8-16-84	0.42	1.93	592
9-25-84	0.33	3.45	552

MW-G

Date	Cu	Cr	TDS
8-16-84	0.18	1.01	444
9-25-84	0.29	9.77	488

Explanation

- Monitoring Well
- Cu Copper
- Cr Total Chromium
- TDS Total Dissolved Solids
- NA Not analyzed

All Concentrations in mg/l

NOTE:

THE DATA INDICATES ABSOLUTE LEVELS OF INDIVIDUAL PARAMETERS AT SPECIFIC ONSITE LOCATIONS. EXPOSURE CALCULATIONS ARE REQUIRED TO ESTIMATE POTENTIAL OFFSITE LEVELS.

FIGURE 4-3 (Sheet 2)
GROUNDWATER QUALITY MAP
McCORMICK & BAXTER
CREOSOTING COMPANY
PORTLAND, OREGON

o Tank Farm

The tank farm occupies an area 200 feet by 300 feet about 100 feet upriver from retort Nos. 1 and 2. There are six tanks in the farm cover designated for the storage of oil, creosote, creosote in oil (two tanks), penta in oil, and process wastewater. In addition to the tanks there is above-ground piping, pumps and motors.

The tank farm area is isolated from the rest of the site by a 4-foot-high concrete wall that surrounds the tank farm. This wall serves as secondary containment of any spills within the tank farm. While the pumps and motors and containment wall are on a concrete base, the remainder of the tank farm is dredged spoils and aggregates.

Monitoring Well-I is just outside the tank farm wall. Groundwater samples taken from MW-I showed high levels of penta and oil and grease. Wood preservative concentrations and migration in the soil around the tank farm appears to be extensive. Soil samples showed high oil and grease concentrations to below 40 feet. Additional soil borings were constructed to determine the horizontal extent of wood preservative migration from the tank farm. BH-1, BH-2, BH-3, and MW-M all showed wood preservative constituents somewhere between 15 to 40 feet deep.

Recent inspections of the penta in oil mix tank No. 6 and the creosote in oil mix tank No. 2 have revealed some minor corrosion of tank interiors but have not detected any leaks. Until the two remaining tanks and the underground pipeline from the main creosote storage tank to the tank farm are inspected, it will not be known if the wood preservatives in the ground are the result of leaking tanks currently in service. Past activities that could have been sources include occasional spills and the use of an 10,000-gallon underground rail tank car for creosote in oil storage.

The highly concentrated layer of surface soil and accumulated residue has been excavated and removed offsite to a Chem Security System, Inc. hazardous waste management facility located near Arlington, Oregon. Plans and specifications for placement of a concrete floor for the tank farm have been prepared and submitted to the DEQ.

The underground rail tank car located at the northwest corner of the tank farm was used to store creosote and oil. The empty tank has not been used for about 12 years, but spills, overflows, or leaks while it was in use may be a source of wood preservatives in the soils between the tank farm and the Willamette River.

o Former Waste Disposal Area

The former waste disposal area is located in the northwest corner of the site along a slight embankment. Waste was placed in a shallow area which was about 150 feet long and 75 feet wide. The soil and groundwater samples taken from MW-E located in this area shows high levels of penta, and oil and grease. Wood preservatives appear to be near the surface. The most highly concentrated sample was collected between 5 to 10 feet below grade. Monitoring Wells-D and -G, downgradient from the area, show high levels of wood preservative constituents from 15 to 30 feet deep and high penta levels in MW-G groundwater. Although MW-F samples contained some preservatives, the concentrations were much lower than those from MW-E, -D, or -G.

Process residues were deposited in this area for only a short time (1968-1970); no wastes have been placed there in the 15 years since. The area is now used to store treated and untreated wood and miscellaneous metal parts. The process waste residues are removed offsite to the Chem Securities System Inc. hazardous waste management facility near Arlington, Oregon.

o Site Surface and Stormwater Outfall

Other areas on the site show varying levels of oil and grease, PCP, PAH, copper, chromium, and arsenic in the surface soils. This is primarily the result of past process activities and spills. This is common at wood preserving plants and is the likely source of wood preservatives in the stormwater outfall. Site drainage is currently collected in open areas within the process area. The process area covers about 150,000 square feet of the site surface. Surface soils in the process area show higher wood preservative constituent levels than most other onsite surface soils.

PRELIMINARY EXPOSURE ASSESSMENT

The available site sampling and testing data, along with reference data on the physical properties of wood preservatives allow for a qualitative assessment of the immediate environmental pathways through which humans could be exposed to wood preservative constituents away from the site. Further sampling and study will concentrate on estimating potential immediate and long-term amounts of preservative residues carried through these pathways. Future work will consider remedial actions to reduce short- and long-term migration of preservative residues below target levels. The human populations considered in this qualitative assessment are the industrial neighbors, the North Portland residents on the hillside east of the plant, any river traffic, and limited unauthorized pedestrian traffic along the bank of the Willamette.

Onsite sampling indicates that arsenic, chrome, and copper are only of marginal concern within the contaminated areas of the plant. Considering the lack of mobility of these metals, which commonly occur in the environment, and that further dilution will occur if these constituents are released offsite, it would appear that the offsite effects of these metals are not an immediate concern. Therefore, pentachlorophenol and creosote are the focus of the following site-specific analysis of potential immediate environmental pathways for offsite human exposure to contaminated soil and associated waters:

- o Domestic (potable) water--Local North Portland residents and industries adjacent to the site use City of Portland domestic water (from a very remote source), so any wood preservative constituents in site soils or groundwater are of no concern with regard to the local potable water supply. Samples taken downstream from the plant have shown no detectable wood preserving constituents. Although there is probably some slight contamination reaching the Willamette River from groundwater flow connecting with the Willamette, or from periodic stormwater flow, these contributions are not likely to be detected compared to the large river flow. Even some local sampling by DEQ has not shown any river water contamination. Any unmeasured trace contamination is not of particular concern because of the known biodegradability of these organic compounds (see Appendix D).
- o River sediments--The "offsite" river sediments contain some contamination from past practices and probably from some groundwater lenses flowing through contaminated zones on the site into the

river. Since the river water above these sediments does not show contamination, the magnitude of this problem appears to be minor. The risk of immediate human exposure appears to be minimal. Sediments would be of specific concern only if major dredging occurred. Again, the biodegradability of the organic constituents in the sediments may make this a self-mitigating problem.

- o Vapor emissions--The constituents involved with the contaminated soils or associated waters have little or no vapor pressure, so volatile emissions are of no concern.
- o Airborne particulates--Theoretically, surface dust can migrate offsite to adjacent industries, local residents, or passing river traffic. But since extensive health studies (see Appendix A) concerning onsite worker exposure indicate that there is no significant health risk onsite, and considering that the dust would be diluted before offsite exposure occurred, it is difficult to imagine any significant consequences through this environmental pathway.

In summary, human exposure from vapor, liquid, or solids containing residues from the contaminated soils and associated waters do not appear to be significant, immediate public health issues. Further study to quantify immediate, as well as long-term pathways of exposure and to study methods for further reducing potential offsite release should be performed to best minimize any long-term risks.

CVR32/034

FUTURE WORK

Section 5 FUTURE WORK

As discussed in Section 3, McCormick & Baxter is proceeding with a program to continue to reduce the potential offsite releases of wood preservatives through improved point source control. This program includes continued efforts to isolate the wood preservation operations from other plant operations; and an intensified inspection and maintenance program. McCormick & Baxter is also performing external and internal inspection of preservative storage and work tanks to make sure there is no release of preservatives to the environment from these tanks.

In addition to site improvements, McCormick & Baxter will continue to collect information on the presence of wood preservative constituents in the site soils, surface waters, and groundwater to further characterize the site. The characterization is required to more accurately define the long-term potential for offsite exposure of wood preservatives from the site. With the additional information needed to more fully characterize the site, a remedial investigation (RI) and feasibility study (FS) will be prepared. The RI/FS will determine if any long-term risks exist which exceed health or environmental criteria. If so, it will identify the lowest cost alternative that is technologically feasible for those areas of the plant site that are sources of offsite releases of preservatives.

Some of the future work has been briefly mentioned in previous sections of this interim report. This section provides a brief summary of the additional data required to complete the characterization of the site. In addition, the RI/FS process is described. A schedule for this future work has also been prepared which includes quarterly progress reports to the DEQ.

FUTURE SITE INVESTIGATIONS

Substantial progress has been made in the last year characterizing the site hydrogeology and identifying the presence of preservatives in the site soils and groundwater. In addition, past and potential current site activities have been evaluated with respect to being potential sources of offsite releases of preservatives. However, additional information is needed to better characterize the site and prepare the RI/FS. This additional information includes:

- o The depth of wood preservatives in the soil near the tank farm. Laboratory analysis of soil samples from MW-I indicate a high concentration of oil and grease at a depth of 35 to 40 feet. A heavy oil fraction that is denser than water was observed

while drilling this monitoring well. It is unknown whether the high oil and grease concentration is due to these heavy oils or is due to contamination of the sample as it was lowered and withdrawn through less dense oils floating on the water inside the auger.

- o Bulk aquifer parameters, particularly hydraulic conductivity. Permeability testing to date has given only approximate values of permeability at the site.
- o Vertical gradients at the site. As indicated in Table 4-1, all monitoring wells installed to date are screened over approximately the same interval. The difference in static water elevation with depth cannot be determined. Because the Willamette River is a groundwater discharge area, an upward vertical gradient is expected. An upward gradient would restrict the downward vertical migration of dissolved constituents.
- o Seasonal variation in groundwater levels. Because the monitoring well network has been in place for only a short time, the response of groundwater levels to seasonal variations in precipitation and river stage is unknown.
- o The areal extent and thickness of low-density oils floating on the water table. Oil has occasionally been found floating on the water surface in MW-D, -G, and -I. The persistence and thickness of the oil layer is not known and needs to be determined.
- o Long-term trends in groundwater quality. Information regarding trends in groundwater quality is necessary to evaluate any long-term effects that past or current site activities may have on groundwater in the area.
- o Vertical extent of wood preservatives in the soil. Soil samples were collected about every five feet but not all samples were analyzed. A review of the laboratory results shows that for some borings there are from 20 to 30 feet between high and low concentrations of wood preservatives. The soil samples between these points should be analyzed to further characterize the presence of wood preservatives for the evaluation of remedial action alternatives. In addition, additional soil samples need to be analyzed for PAH's to assess the presence and extent of migration of creosote.

To collect the additional information that is needed, a multifaceted drilling and data collection program is planned. It is proposed that a deeper well (MW-N) be installed in the vicinity of MW-I. The depth of the wood preservatives near MW-I will be determined by sampling with a standard split spoon at 5-foot intervals while drilling MW-N. In order to prevent contamination of the samples by floating oil, it may be necessary to use an alternate drilling method such as cable tool. This method requires that a temporary steel casing be driven as drilling progresses. The temporary steel casing should form an effective barrier.

After drilling to an estimated depth of 70 feet, a permanent well casing will be installed and the temporary casing pulled back to expose the screen. The screen will extend from 65 to 55 feet below the surface, approximately 20 feet below the bottom of MW-I. The static water level difference between the shallow MW-I and the deeper MW-N will reflect the magnitude and direction of the vertical gradient.

Bulk hydraulic conductivity will be estimated by conducting a 24-hour pumping test at MW-N. A submersible pump will be installed in MW-N and the water levels in MW-N, -I, and possibly -H and -M will be monitored as the pump test progresses. After pumping stops, the water level recovery in the wells will be monitored to provide a check on the drawdown data.

Water levels in all monitoring wells and in the Willamette River will be measured weekly until one year's record has been collected. This will help to identify the seasonal variation in groundwater levels and their relation to river stage.

Each monitoring well will be visually inspected for the presence of oil. If oil is detected floating on the water in any monitoring well during the routine water level measurements, its thickness will be measured using a steel tape and water finding paste such as Kolor-Kut. This paste changes color upon contact with water, allowing accurate determination of the top and bottom of an oil layer.

The current record of groundwater quality data is difficult to interpret because it is too short and because the analyzed constituents are not consistent between wells. It is proposed that a quarterly groundwater sampling program be initiated in April. Subsequent sample collections will take place in July, October, and December to coincide with the seasons.

All monitoring wells will be sampled by bailing with a stainless steel bailer. The bailer will be cleaned between wells with a detergent wash, a tapwater rinse, an acetone rinse,

and a distilled water rinse. Wells will be purged by bailing a minimum of three casing volumes before sampling.

Temperature, pH, and specific conductance will be measured in the field at each well during sampling. The meters will be calibrated and checked in the field against appropriate buffers and standards. The portion of the sample taken for field chemical analysis will be discarded to avoid contaminating the laboratory sample.

Previously collected soil samples that have been kept frozen in CH2M HILL's Corvallis laboratory will be analyzed for the appropriate wood preservative constituents for those areas where certain soil samples were not previously analyzed.

Groundwater and soil samples will be analyzed for pentachlorophenol and screened for total PAH on a gas chromatograph. Inorganic analyses will include copper, total chrome, hexavalent chromium, and arsenic. These six parameters, plus the field pH and specific conductance, will serve as indicator parameters, intended to reflect the effects of past and present site activities.

RI/FS PROCESS

To adequately characterize a site and any possible risks to human health and the environment, it is necessary to view the site from many perspectives, so that all issues are addressed. Furthermore, if a risk is identified, the solution should focus on reducing the risk to an acceptable level and do so in a cost-effective manner. With the multiplicity of technical issues, varying viewpoints, and cost/benefit trade-offs, the characterizing of a risk and its mitigation is a formidable task.

The National Contingency Plan (NCP) acknowledges the complexity of this task and in fact outlines an approach for untangling this maze of technical issues for sites on the National Priorities List (NPL). This is usually referred to as an RI/FS and includes a remedial investigation (RI) for characterizing the site risks, and a feasibility study (FS) for identifying a cost-effective remedy. The NCP also includes a hazard rating system. A site must "present an imminent and substantial danger to public health or welfare, or the environment" and also receive a high rating relative to other sites before it is placed on the NPL. The mere presence of contamination is not sufficient to support NPL listing.

The McCormick & Baxter wood treating facility in Portland is not on the NPL and, therefore, no site remedial actions are required. However, McCormick & Baxter is concerned about

the possibility of any adverse long-term environmental effects from their past and present operations and has chosen to follow the basic RI/FS approach outlined in the NCP as a guideline for long-term control of wood-treating chemicals.

REMEDIAL INVESTIGATION

An RI provides site characterization data including demography, land use, natural resources, climatology, hazardous waste types and distribution, hydrogeology, surface water interactions, biota, and air data. An RI serves to identify any site areas of concern for toxic chemicals and exposure pathways of contamination to potential targets at risk. RI work to date for McCormick & Baxter has been presented in Section 4.

FEASIBILITY STUDY

Sections 300.68g and 300.68h of the NCP provide guidance for the development and initial screening of remedial action alternatives for sites which pose a long-term risk from hazardous substances. A limited number of alternatives would be developed and subjected to initial screening based on three broad criteria: 1) cost, 2) effects of the alternative, and 3) acceptable engineering practices. This NCP guidance will be used as a basis for identifying any long-term risks which exceed health or environmental criteria. If so, it will also assist in developing and screening the remedial action alternatives to leave only those site-specific alternatives that are technically applicable, feasible, and cost-effective.

A preliminary screening of possible remedial technologies for the McCormick & Baxter site has been initiated and is presented in Appendix E. This screening of technologies is based upon current site information and will be updated during the RI/FS. The RI/FS evaluation will combine these technologies into remedial action alternatives which meet the risk assessment criteria for each site contamination source identified.

The remedial technologies remaining after preliminary screening in Appendix E are:

A. Surface Caps

- o Portland cement concrete
- o Bituminous concrete (asphalt)
- o Gravel over geotextile
- o Loam over synthetic membrane over sand
- o Loam over clay

B. Containment Barriers

- o Soil-bentonite slurry wall
- o Cement-bentonite slurry wall
- o Sheet-piling

C. Groundwater Pumping

- o Well points
 - Suction pump system
 - Jet ejector pump system
 - Submersible pump system
- o Deep wells

D. Soil Excavation

- o Backhoes
- o Front-end loaders

E. Sediment Removal

- o Mechanical dredging

F. Water Treatment

- o Aerobic treatment systems
 - Activated sludge
 - Trickling filters
 - Fluidized bed bioreactors
- o Anaerobic treatment systems
- o Precipitation
- o Organic chemical oxidation
- o Flow equalization
- o Activated carbon
- o Liquid/liquid extraction
- o Oil-water separation

Water Disposal

- o Discharge to a publicly owned treatment works
- o Discharge to the river
- o Shallow reinjection

Soil Disposal

- o Offsite landfill
- o Offsite incineration

These technologies will be combined into alternatives that will then be evaluated in detail to determine which is the most cost-effective. Per Section 300.68 of the NCP, the most cost-effective response action is defined as: "the lowest cost alternative that is technologically feasible and reliable and which effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare, or the environment."

A Public Health Evaluation and an Environmental Analysis are used to determine the short- and long-term effects if no action is implemented or if any of the response action alternatives are implemented.

PUBLIC HEALTH EVALUATION

Evaluation of the short-term and long-term effects of toxic chemical contamination on the public consists of three major tasks. First, baseline site data from a remedial investigation are needed to identify and locate site contamination in surface water, groundwater, soils and sediments, or air which may threaten human health. Second, an Exposure Assessment is done for each site scenario considered (no action and remedial actions) to estimate potential concentrations of toxic chemicals at human population target points of concern. Chemicals are selected for use in the Exposure Assessment based on considerations of toxicity, persistence, mobility, and site contamination level and extent.

The third step, which may start during the RI, is to analyze human health criteria data and regulatory compliance data for specific toxic chemicals of concern. Based on these data and the Exposure Assessment, standards are developed to allow the evaluation of whether short-term or long-term human health effect risks are acceptable for a given site scenario.

ENVIRONMENTAL ANALYSIS

The Environmental Analysis considers short-term and long-term effects of toxic chemical contamination on the environment. For the Environmental Analysis, the target points of concern are plant and animal life. The Environmental Analysis process is similar to the Public Health Evaluation. Baseline site data are used in the RI to identify environmental points of concern for short- and long-term effects of specific toxic chemicals. Different possible exposure scenarios are considered and evaluation criteria are established based on exposure data and existing data on environmental effect levels and regulatory compliance levels.

SCHEDULE

The anticipated schedule for future work is provided in Table 5-1.

CVR33/020

ACTIVITY	1985												1986											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
ADDITIONAL DATA COLLECTION																								
GROUNDWATER																								
Installation of Monitoring Well-N																								
Pump test																								
Water level measurements																								
Oil observations and measurements																								
Monitoring well sampling and analysis																								
SOILS																								
Sampling and analysis of Monitoring Well-N soils																								
Analysis of previously collected soils																								
SURFACE WATER																								
Flow measurements of stormwater outfall																								
Sampling and analysis of stormwater outfall																								
Inspection of Willamette River for oil																								
PROCESS																								
Inspection of remaining tanks in tank farm																								
Inspection of underground pipeline																								
DELIVERABLES																								
Status Reports																								
Draft Remedial Investigation (RI) Report																								
Draft Feasibility Study (FS) Report																								
Final RI/FS Report																								

TABLE 5-1
SCHEDULE FOR FUTURE
ACTIVITIES

McCORMICK & BAXTER
CREOSOTING COMPANY
PORTLAND, OREGON

BIBLIOGRAPHY

Section 6
BIBLIOGRAPHY

Alexander, M., and M.I.H. Aleem. Effect of Chemical Structure on Microbial Decomposition of Aromatic Herbicides. Journal of Agricultural Food Chemistry. 9(1):44-47. 1961.

American Petroleum Institute. Manual on Disposal of Refinery Wastes, Vol. I. Wastewater Containing Oil (6th Edition), 1969.

American Wood Preservers Institute. OPP-30000/30: Rebuttable Presumptions Against Registration and Continued Registration of Pesticide Products Containing Pentachlorophenol. Vol. 1: Discussion and Analysis of Risks and Benefits Associated with Pentachlorophenol Used As a Wood Preservative. Submitted to U.S. Environmental Protection Agency in response to EPA Position Document (PD-1). February 12, 1979.

American Wood Preservers Institute. OPP-30000/28: Rebuttable Presumptions Against Registration and Continued Registration of Pesticide Products Containing Coal Tar, Creosote, and Coal Tar Neutral Oil. Vol. 1: Discussion and Analysis of Risks and Benefits Associated with Coal Tar, Creosote, and Coal Tar Neutral Oil Used as Wood Preservatives. Submitted to U.S. Environmental Protection Agency in response to EPA Position Document 1 (PD-1). February 12, 1979.

American Wood Preservers Institute. OPP-30000/29: Rebuttable Presumptions Against Registration and Continued Registration of Pesticide Products Containing Inorganic Arsenic. Vol. I: Discussion and Analysis of Risks and Benefits Associated with Inorganic Arsenic Used as a Wood Preservative. Submitted to the U.S. Environmental Protection Agency in response to EPA Position Document 1 (PD-1). February 12, 1979.

American Wood Preservers Association. Report of Special Committee of Environmental Protection Agency Liason. 1975.

Arsenault, R. D. Pentachlorophenol and Contained Chlorinated Dibenzodioxins in the Environment. American Wood Preservers Association, 1976.

Bedient, P., A. Rogers, T. Bourette, M. Tomson, and T. Wang. Groundwater Quality at a Creosote Waste Site. Groundwater. Vol. 22, No. 3, May-June 1984.

Bevenue, A., and H. Beckman. Pentachlorophenol: A Discussion of Its Properties and Its Occurrence as a Residue in Human and Animal Tissues. Residue Review 19:83-134. 1967.

- Bowen, H.J.M. Trace Elements in Biochemistry. Academic Press, New York. 1966.
- Braun, W.H., J.D. Young, M.W. Sauerhoff, G.E. Blau, and P.J. Gehring. The Pharmacokinetics and Metabolism of Pentachlorophenol in Rats and Monkeys. Toxicol. Appl. Pharmacol. 37:94. 1976.
- Cherry, William R., and Brian P. Jessen. Utilization of Molecular Oxygen and Sunlight in the Oxidative Purification of Water. Water Research Institute, West Virginia University, Morgantown, West Virginia. Report No.: W83-02134; OWRT-A-042-WVA(1). 1982.
- Choi, J., and S. Aomine. Effects of the Soil on the Activity of Pentachlorophenol. Soil Sci. Plant Nutr. 18(6):255-260. 1972.
- Choi, J., and S. Aomine. Adsorption of Pentachlorophenol by Soils. Soil Sci. Plant Nutr. 20(2):135-144. 1974.
- Choi, J., and S. Aomine. Mechanisms of Pentachlorophenol Adsorption by Soils. Soil Sci. Plant Nutr. 20(4):371-379. 1974a.
- Chu, J. P. and E. Kirsch. Microbial Degradation of PCP and Related Chlorophenols. Purdue University, 1972.
- CH2M HILL. Western Processing Feasibility Study (Draft). Prepared for U.S. EPA. Bellevue, Washington. December 1984.
- Crosby, D. G. and Nizar Hamadmad. Photoreduction of PCB's. Agricultural and Food Chemistry. Vol. 19, No. 6, p. 1171. November/December 1971.
- Crosby, D. G. Environmental Chemistry of Pentachlorophenol. Pure and Applied Chemistry. Vol. 53 (5). Pp. 1052-1080. 1981.
- Cserjesi, A. J. and E. L. Johnson. Methylation of Pentachlorophenol by *Trichoderma Virgatum*. Canadian Journal of Microbiology. Vol. 18, 1972.
- Cserjesi, A. J. Detoxification of Chlorinated Phenols. Department of the Environment, Canadian Forestry Service, Western Forest Products Laboratory, Vancouver 8, British Columbia, Canada. December 1972.
- Daros, B., et al. Wood Preserving Industry Multimedia Emission Inventory. EPA-600/52-81-066. 1981.

Dust, J. and W. Thompson. Pollution Control in the Wood-Preserving Industry, Part III. Forest Products Journal. Vol. 22, No. 12, pp. 25-30, December 1972.

Dust, J., W. Thompson, A. Shindala, and N. Francingues. Chemical and Biological Treatment of Wastewater from the Wood Preserving Industry. N.D.

Edgehill, R. and R. Finn. Activated Sludge Treatment of Synthetic Wastewater Containing PCP. Biotechnology and Bioengineering. Vol. 25, pp. 2165-2176. 1983.

Ferris, J. and D. Knowles. The Slug Injection Test for Estimating the Coefficient of Transmissibility of an Aquifer. In: Methods of Determining Permeability, Transmission, and Drawdown. R. Bentall, ed. U.S. Geological Survey Water Supply Paper 1536-1, 339 p. 1963.

Finn, R. K. Use of Specialized Microbial Strains in the Treatment of Industrial Waste and in Soil Decontamination. 1983.

Fisher, C.W. Koppers' Experience Regarding Irrigation of Industrial Effluent Waters and Especially Wood-Treating Plant Effluents. Proceedings of the Conference on Pollution Control in the Wood-Preserving Industry. W.S. Thompson, ed. Mississippi For. Prod. Lab., Miss. State Univ., State College, Miss. Pp. 232-248. 1971.

Guthrie, M., E. Kirsch, R. Wukasch, and C. Grady Jr. Pentachlorophenol Biodegradation-II Anaerobic. Water Resources. Vol. 18, No. 4, pp. 451-461. 1984.

Hackett, Murray, et al. The Toxicology of Pentachlorophenol and Its Contaminants. Corvallis, Oregon: OSU Department of Civil Engineering. 1984.

Hawley, Gessner G. The Condensed Chemical Dictionary. San Francisco, California: Van Nostrand Reinhold Company. 1981.

Herbes, S. L., G. R. Southworth, and D. L. Shaeffer. Critical Pathways of Polycyclic Aromatic Hydrocarbons in Aquatic Environments. In: The Scientific Basis of Toxicity Assessment. H. Witschi, ed. Elsevier. 1980. Pp. 113-128.

Hetrick, L.A. The Comparative Toxicity of Some Organic Insecticides as Termite Soil Poisons. Journal of Economic Entomology. 45(2):235-237. 1952.

Hilton, H. Wayne and Quan H. Yuen. Adsorption of Several Pre-emergence Herbicides by Hawaiian Sugar Cane Soils. Agricultural and Food Chemistry. Vol. 11, No. 3, May-June 1963.

Hogenson, G.M., and B.L. Foxworthy. Ground Water in the East Portland Area, Oregon. U.S. Geological Survey Water Supply Paper 1793, 78 p. 1965.

Howard, P. H., J. Saxena, and H. Sikka. Determining the Fate of Chemicals. Environmental Science Technology Vol. 12, No. 4, 1978. Pg. 398-407.

Ide, A., Y. Niki, F. Sakamoto, I. Watanabe, and H. Watanabe. Decomposition of Pentachlorophenol in Paddy Soil. Agric. Biol. Chem. 36(1):937-1844?. 1972.

Kaufman, D. D. Degradation of Pentachlorophenol in Soil, and by Soil Microorganisms. In: Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology. K. R. Rao, ed. 5 (27) 1978. Pp. 27-39.

Kirsch, E. J. and J. E. Etzel. Microbial Decomposition of Pentachlorophenol. Water Pollution Control Federation Journal. Vol. 5, No. 2, February 1973.

Kirsch, E. J. Biodegradability of Pentachlorophenol in a Model Wastewater Treatment System. Purdue University Research Report. N.D.

Kobayashi, K. and H. Akitake. Studies on the Metabolism of Chlorophenols in Fish. Bulletin of the Japanese Society of Scientific Fisheries. 41(1)87-92(1975).

Konasewich, D. E., et al. Chlorophenate Wood Protection--Recommendations for Design and Operation. British Columbia, Canada: BC Ministry of Environment. 1983.

Kuwatsuka, S. and M. Igarashi. Degradation of PCP in Soils. Soil Science Plant Nutrients. 21, 405-414, 1975.

Lee, R.F., W.S. Gardner, J.W. Anderson, J.W. Blaylock, and J. Barwell-Clarke. Fate of Polycyclic Aromatic Hydrocarbons in Controlled Ecosystem Enclosures. Environmental Science and Technology. 12(7):832-837. 1978.

Liu, Dickson, William Strachan, Karen Thomson, and Kazimiera Kwasniewska. Determination of the Biodegradability of Organic Compounds. Environmental Science and Technology. Vol. 14, No. 7, July 1981.

Loustalot, A.J., and R. Ferrer. The Effect of Some Environmental Factors on the Persistence of Sodium Pentachlorophenate in the Soil. Proceedings of the American Association of Horticultural Science. 56:294-298. 1950.

Lu, P.Y., R.L. Metcalf, and L.K. Cole. The Environmental Fate of ^{14}C -Pentachlorophenol. In: Pentachlorophenol. R.K. Rao, ed. Plenum Press, New York. Pp. 53-66. 1978.

Lu, Po-Yung, et al. The Environmental Fate of ^{14}C -Pentachlorophenol in Laboratory Model Ecosystems. Environmental Science. Vol. 12. N.D.

Lu, Po-Yung, et al. Environmental Fate and Biodegradability of Benzene Derivatives as Studies in a Model Aquatic Ecosystem. Environmental Health Perspectives. Vol. 10. Pp. 269-284. 1975.

Mackah, D. and W. Y. Shio. Aqueous Solubility of Polynuclear Aromatic Hydrocarbons. Journal of Chemical and Engineering Data. Vol. 22, No. 4, 1977. Pp. 399-402.

McGinnis, G. Biological and Photochemical Degradation of Pentachlorophenol and Creosote. Proceedings of the Hazardous Waste Treatment and Disposal in the Wood Preserving Industry Conference. Mississippi Forest Products Laboratory. March 1984. Pp. 115-137.

Merck & Co. Inc. The Merck Index: Tenth Edition. Martha Windholz, ed. Rahway, New Jersey. 1983.

Middlebrooks, E.J. and E.A. Pearson. Wastes from the Preservation of Wood. In: Proceedings, 29th Purdue Industrial Waste Conference. 1968.

Mississippi State University. Unpublished data in the files of the Mississippi Forest Products Laboratory. 1975.

Mississippi State University. Unpublished data in the files of the Mississippi Forest Products Laboratory. 1979.

Moos, L.P., E.J. Kirsch, R.F. Wukasch, and C.P.L. Grady, Jr. Pentachlorophenol Biodegradation--I: Aerobic. Vol. 17, No. 11., Pp. 1575-1584. Great Britain: Pergamon Press Ltd. 1983.

Munakata, K., and M. Kuwahara. Photochemical Degradation Products of Pentachlorophenol. Residue Review 25:13-23. 1969.

Munakata, Katsura and Masau Kuwahara. Photochemical Degradation Products of Pentachlorophenol. Nagoya University, Nagoya, Japan. N.D.

Murthy, N. and D. Kaufman. Anaerobic Soil Degradation of PCP. Bare-West, ARC, USDA, Beltsville, Maryland. N.D.

Pierce, R.H., and D.M. Victor. The Fate of Pentachlorophenol in an Aquatic Ecosystem. In: Pentachlorophenol. K.R. Rao, ed. Plenum Press, New York, N.Y. 1978.

Plimmer, J. R. The Photochemistry of Halogenated Herbicides. N.D.

Sax, Newton Irving. Dangerous Properties of Industrial Materials. San Francisco, California: Van Nostrand Reinhold Company. 1979.

Suzuki, T., and K. Nose. Decomposition of Pentachlorophenol in Farm Soil. (Part 2). Penta Metabolism by a Microorganism Isolated from Soil. Noyaku Seisan Gijutsu. Japan, 26:21-24. 1971.

Thompson, W.S. and J.V. Dust. Pollution Control in the Wood Preserving Industry, Part 2. In-Plant Process Changes and Sanitation. Forest Products Journal. Volume 22, No. 7. 1972.

Thuoston, Robert V., et al. A Review of the EPA Red Book: Quality Criteria for Water. Bethesda, Maryland: American Fisheries Society Water Quality Section. 1979.

U.S. Department of Agriculture. The Biologic and Economic Assessment of Pentachlorophenol/Inorganic Arsenals/Creosote. Volume 1: Wood Preservatives. Cooperative Impact Assessment Report. Technical Bulletin No. 1658-1. November 4, 1980.

U.S. Department of Agriculture. The Biologic and Economic Assessment of Pentachlorophenol, Inorganic Arsenicals Creosote. Technical Bulletin No. 1658-1. 1982.

U.S. Department of Health and Human Services. Registry of Toxic Effect of Chemical Substances. Vols. 1 through 3. Rodger Tutken and Richard J. Lewis, eds. Cincinnati, Ohio. 1983.

U.S. Environmental Protection Agency. Pretreatment Standards: Wood-Preserving Segment of the Timber Products Processing Industry. Contractor's Draft Development Document. 1976.

U.S. Environmental Protection Agency: Environmental Health Advisory Committee Science Advisory Board. Report of the Ad Hoc Study Group on Pentachlorophenol Contaminants. EPA/SAB/78/001. 1978.

U.S. Environmental Protection Agency. Industrial Environmental Research Laboratory. Dioxins. Cincinnati, Ohio. November 1980.

U.S. Environmental Protection Agency. Creosote, Pentachlorophenol, and Inorganic Aresenicals; Decision to Postpone Effective Dates of Restricted Use Classification and Procedures to Certify Pesticide Applicators. EPA Notice: OPP-41001; PH-FRL 2709-1. Federal Register. Vol. 49, No. 212. October 31, 1984.

U.S. Environmental Protection Agency. Creosote, Pentachlorophenol, and Inorganic Arsenals; Intent to Cancel Registrations of Pesticide Products Containing Creosote, Pentachlorophenol (including its Salts) and the Inorganic Arsenicals; Determination Concluding the Rebuttable Presumption Against Registration of the Wood Preservative Uses of Pesticide Products; Availability of Position Document. EPA Notice: PP-30000/28F; PH-FRL 2630-4. Federal Register. Vol. 49, No. 136. July 13, 1984.

U.S. Environmental Protection Agency/Office of Pesticides and Toxic Substances. Wood Preservative Pesticides: Creosote/Pentachlorophenol/Inorganic Arsenicals. Position Document 4. July 1984.

Vela, G. and J. Rainey. Microbiological Degradation of Phenol in the Effluent From a Wood Treatment Plant. Texas Journal of Science. Vol. 27, No. 1, March 1976.

Verschuerer, Karel. Handbook of Environmental Data on Organic Chemicals. San Francisco, California: Van Nostrand Reinhold Company. 1977.

Wallin, B., A. Condren, and R. Walden. Removal of Phenolic Compounds from Wood Preserving Wastewater. EPA-600/S2-81-043. April 1981.

Watanabe, I. Pentachlorophenol-Decomposing and PCP-Tolerant Bacteria in Field Soil Treated with PCP. Vol. 9, pp. 99-103. Pergamon Press 1977, Great Britain.

White, J.T., T.A. Bursztynsky, John D. Crane, and Richard H. Jones. Treating Wood Preserving Plant Wastewater by Chemical and Biological Methods. Gainesville, Florida: Environmental Science and Engineering, Inc. Prepared by Forest Products Division, Koppers Company, Pittsburgh, Pennsylvania. September 1976.

Williams, R.T. Detoxification Mechanisms. 2nd Ed., John Wiley and Sons, Inc., New York, N.Y. 796 p. 1959.

Wilson, J., W. Dunlap, R. Crosby, and J. Chang. Adaption of Groundwater Microorganisms at a Creosote Waste Disposal Site. N.D.

Wilson, John T., William J. Dunlap, Roger L. Cosby, Jeng Chang Chang, and William C. Ghiorse. Adaptation of Ground-Water Microorganisms at a Creosote Waste Disposal Site. Proceedings of the 186th National Meeting of the American Chemical Society, Division of Environmental Chemistry. Vol. 23, No. 2, Pp. 294-296. Washington, D.C.: American Chemical Society. 1983.

Wukasch, R. L. Grady Jr., and E. Kirsch. Prediction of the Fate of Organic Compounds in Biological Wastewater Treatment Systems. Water-1980: American Institute of Chemical Engineers Symposium Series. Vol. 77, No. 209, pp. 137-143. 1981.

Young, H.C., and J.C. Carroll. The Decomposition of Pentachlorophenol When Applied as a Residual Pre-emergence Herbicide. Agron. J. 43:504-507. 1951.

CVR33/051

APPENDIX A
COST-BENEFIT ANALYSIS
FOR WOOD PRESERVATIVES

Appendix A
COST-BENEFIT ANALYSIS FOR WOOD PRESERVATIVES

Our nation's forest lands are a vast natural resource that we depend on for diversity of wood products. The weight of round wood used in the United States each year is comparable to that of all steel, aluminum, Portland cement, and plastic products combined (USDA). The length of time that wood products can be used greatly influences our ability to maintain adequate supplies of forest land resources. The service life of wood is limited due to attack by insects, fungi, bacteria, and marine borers.

Wood preservatives are used extensively to greatly prolong the service life of wood. Treated wood generally has a service life at least five times longer than untreated wood. An estimated 44.5 million pounds of pentachlorophenol, 42 million pounds of inorganic arsenicals, and 124 million gallons of creosote and coal tar are used annually to treat over 327 million cubic feet (USDA). Ninety-nine percent of these pesticides are used as wood preservatives.

Penta was introduced as a wood preservative in the 1930's. Since penta is a solid at ambient temperatures and is only slightly soluble in water, it must be dissolved in petroleum solvents for use as a preservative. The water soluble sodium salt of pentachlorophenol is used to control sapstain fungi. Penta is the major wood preservative used for poles, cross-arms, fence posts, mill work, particle board, plywood, and sapstain control in green lumber and poles.

There are three inorganic arsenical preservatives: fluor chrome arsenic phenol (FCAP patented in 1918), ammoniacal copper arsenate (ACA, patented in 1939), and three types of chrome copper arsenate (CCA Type A, patented in 1938; CCA Type B, patented in 1947; and CCA Type C, patented in 1968). Inorganic arsenicals are the major wood preservatives used for lumber and timbers.

Coal and wood tar products have been used as wood preservatives since Biblical times. The commercial use of creosote and coal tar as wood preservatives began in 1838 in England with the development of a practical pressure-treating process. Creosote solutions are the major wood preservatives used for crossties, switch ties, landscape ties, piling, and ground line treatment of utility poles in service.

LEGAL BACKGROUND FOR PESTICIDE REGISTRATION

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) promulgated a statutory standard for registration of pesticides. This standard requires that there not be "any

unreasonable risk to man or the environment, taking into account the economic, social and environmental costs and benefits of the use of any pesticide" (EPA PD4). Under FIFRA, the Administrator may cancel a pesticide registration or modify the terms and conditions of registration whenever it is determined that the pesticide does not meet this statutory standard.

40 CFR 162.11 sets forth the Rebuttable Presumptions Against Registration (RPAR) process to identify pesticides that may not satisfy the statutory registration standard. The EPA initiates the RPAR process by publishing a notice in the Federal Register stating that a pesticide meets or exceeds regulatory risk criteria. After the RPAR has been issued, registrants and others interested are "invited to review the data upon which the presumption is based and to submit data and information to rebut the presumption by showing that the Agency's initial determination of risk was in error, or by showing that use of the pesticide is not likely to result in any significant exposure to humans or the environment with regard to the adverse effects in question." The respondents may also submit data pertaining to the economic, social, and environmental benefits of using the pesticide.

Based on the available evidence on risks and benefits of using a pesticide, EPA publishes a Notice of Determination stating a final position on the pesticide registration. Any terms or conditions of registration that might reduce the risks of use to sufficient levels where they are outweighed by the benefits of use are stated.

On October 18, 1978, EPA issued RPAR's on creosote, inorganic arsenicals, and pentachlorophenol. Following the issuance of these RPARs, numerous organizations including the U.S. Department of Agriculture, the U.S. Environmental Protection Agency, the State Land-Grant Universities, and the American Wood Preservers Institute, made a comprehensive effort to compile available scientific information and to provide a sound technical evaluation of the benefits and exposure risks. A renowned 20-member team from the USDA, EPA, and the state land-grant universities and over 40 associates, pooled their expertise in a Cooperative Impact Assessment Report (November 1980) of the benefits/risks of using wood preservatives, including the exposure of workers and the public. The following sections briefly summarize the conclusions reached after an exhaustive review of the issues associated with the use of wood treating chemicals. (See the bibliography in this report for a partial list of the hundreds of references consulted in this evaluation.)

SUMMARY OF EFFECTS OF CANCELLATION

The conclusion of the exhaustive Cooperative Impact Assessment Report on wood preservatives was that there are no practical chemical alternatives for creosote, pentachlorophenol and inorganic arsenicals. It was estimated that the cancellation of use of these preservatives would cost \$4.5 to \$6.3 billion annually (1979 prices) based on 86 percent of the pressure treated products alone. This would be an increase of three to four times the annual total value of products containing wood preservatives. This estimated annual cost increase of cancellation assumes that the supply of alternate chemicals or materials is sufficient to meet a demand shift from treated wood at existing prices of these alternates. However, alternate material shortages and price increases would likely result.

Other effects not considered in this analysis were: increases in the amount of energy required to produce substitute products (all of which are more energy-intensive than treated wood), increased dependence on imports of non-wood raw materials and energy, lost investment of existing installation and maintenance equipment, and cross-sectional and regional employment shifts. If untreated wood only were substituted for treated wood, an additional 19 billion board feet of timber would be needed annually.

SUMMARY OF EXPOSURE INFORMATION

PENTACHLOROPHENOL

Studies have shown that the primary toxic concern in commercial pentachlorophenol is due to its dioxin contaminants. Specifically, isomers of hexachlorodibenzo-p-dioxin (HxCDD) have been identified as the contaminants of most concern in pentachlorophenol. HxCDD should not be confused with the much more toxic and notorious 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD).

Physical properties of HxCDD make it of less concern than pentachlorophenol as an environmental constituent. For example, one study concluded that inhalation exposure to HxCDD would be negligible in comparison to pentachlorophenol due to its very low relative vapor pressure. Other studies have demonstrated that HxCDD binds very tightly to soil and by itself does not migrate in the environment.

Intake of pentachlorophenol through ingestion or dermal absorption for workers at commercial wood treatment facilities can vary widely depending on specific operating procedures and personal hygiene practices. Human exposure to penta and HxCDD at commercial wood treatment facilities has been calculated using measured urine penta levels (USDA). These

results show that calculated safety factors for lifetime occupational exposures to penta range from 25 to 1,526 and range from 1,078 to 65,789 for HxCDD (HxCDD is more toxic but there is far less chance for exposure).

The safety factors are the amount by which the EPA-accepted no-observed-effect-level (NOEL) for teratogenic/fetotoxic effects exceeds the calculated exposure. The NOEL limits themselves also contain additional margins of safety.

Penta and HxCDD exposure rates at commercial facilities were also calculated for inhalation using two different approaches: using reported air penta levels for wood treatment plants and using chemical vapor pressure data (USDA). Both approaches gave results showing even greater safety factors for both chemicals than were calculated using the urine penta level approach.

The terms of registration for commercial use include that: effective in 18 months the amount of HxCDD in technical pentachlorophenol will be reduced to less than one-fifteenth the current level allowed. This requirement will even further increase the safety margin for HxCDD exposure.

INORGANIC ARSENICALS

EPA and USDA studies show that there is little or no exposure of workers to arsenicals in ACA treating plants, like McCormick & Baxter, where all arsenicals are used in closed systems. These studies show that arsenate released into the environment is an unlikely source of exposure due to the following:

- o Arsenate binds tightly to soils and becomes unavailable for plant uptake or leaching.
- o Arsenic in water is sorbed by sediments and becomes unavailable for plant uptake or leaching.
- o Arsenate vaporization is very low. A conservative estimate for the concentration of inorganic arsenic in the air at treatment plants was accepted by EPA to be 10 micrograms per cubic meter. This is at the OSHA air quality criteria limit.

The mobility of copper and chromium, other toxic metals found in inorganic arsenicals, have been shown to be limited in the environment due to adsorption onto soils. These metal levels should be compared with background levels found in site soils, rather than comparing them only to an absolute regulatory toxicity standard. Normal soils can contain levels of metals that exceed these standards. Background metal levels in normal soils have been shown to vary from 2 ppm to

100 ppm for copper, from one ppm to 1,000 ppm for chromium, and from one ppm to 50 ppm for arsenic. Average levels for these metals in normal soils have been shown to be 30 ppm, 100 ppm, and 10 ppm, respectively.

CREOSOTE

Creosote is a composition of several polycyclic aromatic hydrocarbons (PAH's) that vary in toxicity and physical and chemical properties. Human intake of creosote through ingestion or dermal absorption at commercial wood treatment facilities can vary widely depending on operating procedures and personal hygiene practices.

An air-monitoring study was conducted in 1976 at Koppers wood treating facility by the National Institute of Occupational Safety and Health (NIOSH). Results from a stationary sampling device showed that there was 0.12 mg per cubic meter of particulate polycyclic organic materials (PPOM) in a creosote wood treating area. This level is below the Occupational Safety and Health Administration (OSHA) permissible limit for PPOM of 0.2 mg per cubic meter. To date, there are no definitive data that show concentrations of airborne creosote constituent vapors or particulates that workers may be exposed to in a wood treatment plant, and no definitive data that show that the long-term health effects of these constituents would be unacceptable.

AGENCY CONCLUSIONS

In Position Document 2/3 (February 19, 1981), the EPA received and addressed comments that repounded to the RPAR Notice, Position Document 1 (PD1). In July 1984, the EPA released its final Position Document 4 that concluded "there will be no unreasonable adverse effects posed to man or the environment" for commercial uses of the three wood preservatives, provided that the terms of registration described in Position Document 4 (PD4) are followed. Several groups have indicated that the toxicological data and methodology behind PD4's terms of registration are too conservative and have led to unnecessarily stringent restrictions on use. EPA's PD4 has therefore been suspended pending the outcome of cancellation hearings.

The EPA prescribed a number of low-cost precautions (e.g., wearing gloves or other common protective clothing, prohibiting eating, drinking, and smoking during application) for specific commercial wood-preserving operations as conditions accompanying continued registration. These precautions and other common safety procedures are considered sufficient protection for workers who are exposed to the preservatives

on a daily basis. Use of the preservatives was also restricted to registered users to prevent the possible risk to untrained persons. Interior use was also restricted.

The EPA position on home and farm use of pentachlorophenol and creosote is that uses are to be restricted to certified applicators only. The agency rationale for these restrictions is that, even though adequate margins of safety are likely for applicators wearing gloves and following basic hygiene guidelines, a "worst case analysis" indicated that untrained applicators might not wear gloves, could splash these wood preservatives on their skin during application, might eat food during application, or otherwise expose themselves to unacceptable wood preservative levels. These possible "worst case" considerations led EPA to conclude that the risks for over-the-counter use of creosote and pentachlorophenol were unacceptably high relative to the benefits of over-the-counter use. A similar restriction on home and farm use of inorganic arsenicals was not necessary since this pesticide was not available over the counter.

IMPLICATIONS FOR IMMEDIATE PUBLIC EXPOSURE

The EPA conclusion that "there will be no unreasonable adverse effects posed to man or the environment, provided that the pesticide registration terms are met," applies to the highest possible exposure risk targets--workers at commercial wood-preserving operations. The exposure of any neighboring public to wood-preserving constituents from these facilities will intuitively be orders of magnitude lower than for workers onsite, due to dilution effects of being further removed from the constituent sources. Therefore, it logically follows that if the exposure of workers to wood preservatives is reasonable, then any offsite exposure will have even greater margins of safety.

CVR32/039

APPENDIX B
BORING LOGS

WELL CONSTRUCTION DATA

Date Drilled	MW-A 9/27/83	MW-B 9/27/83	MW-C 9/27-28/83	MW-D 9/28/83
Boring Diameter	7"	7"	7"	7"
Boring Depth	29'	29'	25'	32'
Casing Depth	27'	23'	24'	32'
Casing Diameter	2"	2"	2"	2"
Casing Material	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC	Sch 40 PVC
Perforated Interval	22'-27'	18'-23'	19'-24'	27'-32'
Perforation Thickness	0.02"	0.02"	0.02"	0.02"
Filter Pack Material	1 mm sand	1 mm sand	1 mm sand	1 mm sand
Filter Pack Interval	22'-29'	16'-29'	18'-25'	25'-32'
Annular Seal Depth	10'	16'	4'	15'
Annular Seal Material	Bentonite slurry with 5 sacks cement per yard			

Source: Aqua Resources, Inc.

MW-A SUMMARY BORING

<u>Depth Below Surface (ft)</u>	<u>Lithologic Description</u>	<u>Soil Classification</u>
0	Brown medium sand; some 1/4-inch gravel	SP
5	Brown medium sand; no gravel	SP
10	Brown medium sand; no gravel	SP
15	Brown medium sand; no gravel; moist at 18 feet	SP
20	Gray-black medium sand	SP
20.5	Gray-black sandy silt with some organics	
23	Black clayey silt on augers	
25	Gray-black medium sand; some lenses/streaks of brown medium sand and gray-black silty fine sand; some organics	SP

Source: Aqua Resources, Inc.

MW-B SUMMARY BORING

<u>Depth Below Surface (ft)</u>	<u>Lithologic Description</u>	<u>Soil Classification</u>
0	Medium gray-black sand, earth odor	SP
5	Medium gray sand with gravel to 1/2 inch	SP
	Gravelly medium brown sand with 1/4-inch gravel; earthy odor	
10	Gravelly black medium sand	SP
15	Brown medium sand; no gravel	SP
20	Organics--bark and wood chips	PT
25	Organics--bark and wood	PT
25	Clayey silt with organics (bark and wood)	OL

Source: Aqua Resources, Inc.

MW-C SUMMARY BORING

<u>Depth Below Surface (ft)</u>	<u>Lithologic Description</u>	<u>Soil Classification</u>
0	Brown fine-medium sand	SP
5	Brown fine-medium sand	SP
10	Brown fine-medium sand, moist	SP
15	Brown and black, medium coarse sand; bottom 8 inches saturated (water)	SP
20	Medium sand, saturated	SP

Source: Aqua Resources, Inc.

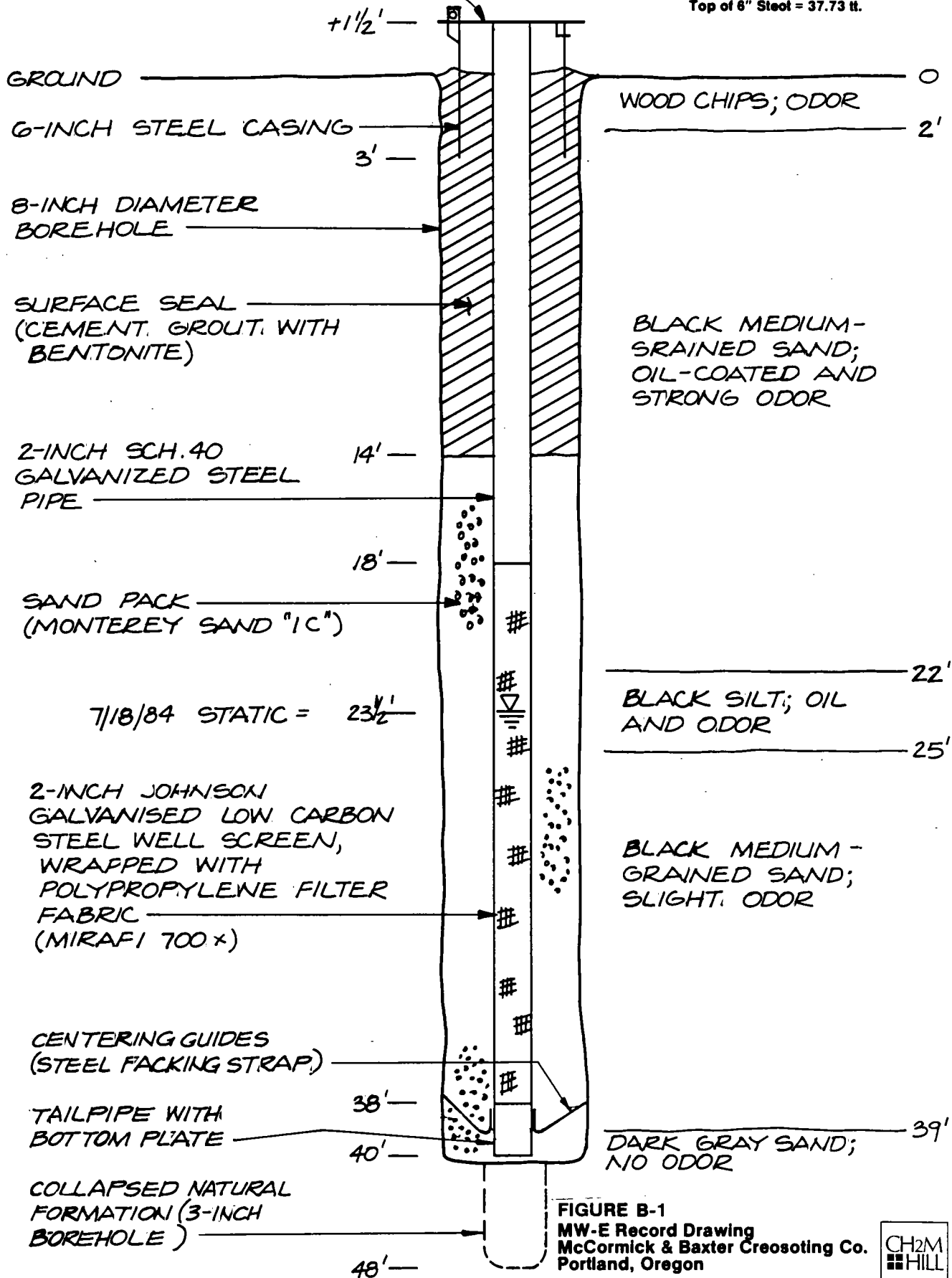
MW-D SUMMARY BORING

<u>Depth Below Surface (ft)</u>	<u>Lithologic Description</u>	<u>Soil Classification</u>
0		SP
5	Brown medium sand--dry	SP
10	Brown medium sand--dry, very loose	SP
15	Brown, gray, and white medium sand--dry, very uniform	SP
18	Auger cuttings--medium sand with oily sheen, strong creosote odor	SP
20	Brown, gray, and white medium sand--moist, some creosote odor	SP
25	Brown, medium sand--oily sheen, strong creosote odor	SP
30	Medium sand--saturated with black oil, strong creosote odor	SP

Source: Aqua Resources, Inc.

STEEL PROTECTIVE CAP
WITH TAB FOR PADLOCK

CASING ELEVATIONS (MSL)
Top of 2" Steel = 37.58 ft.
Top of 6" Steel = 37.73 ft.



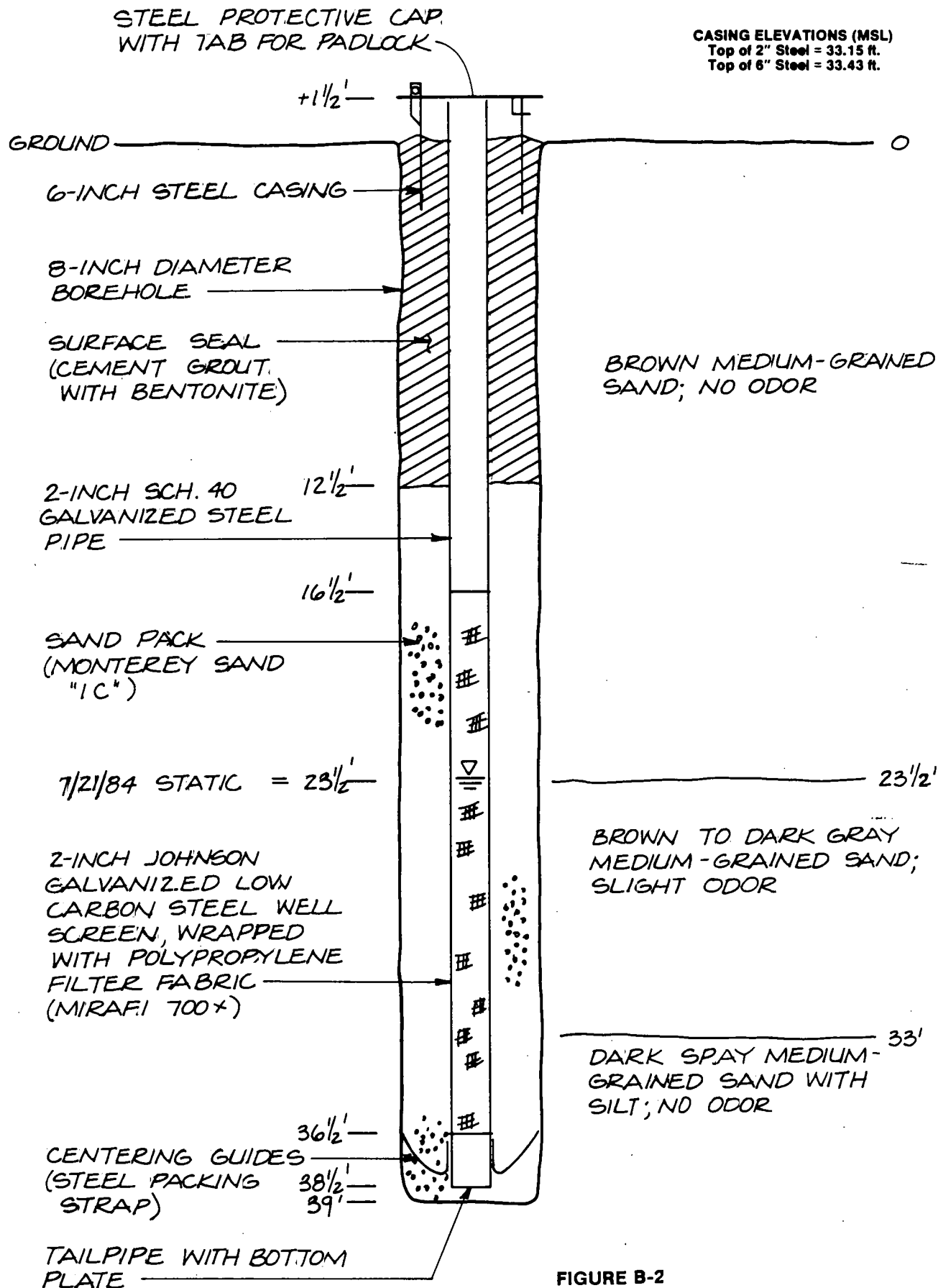


FIGURE B-2
MW-F Record Drawing
McCormick & Baxter Creosoting Co.
Portland, Oregon



STEEL PROTECTIVE CAP
WITH TAB FOR PADLOCK

CASING ELEVATIONS (MSL)
Top of 2" Steel = 34.30 ft.
Top of 6" Steel = 34.43 ft.

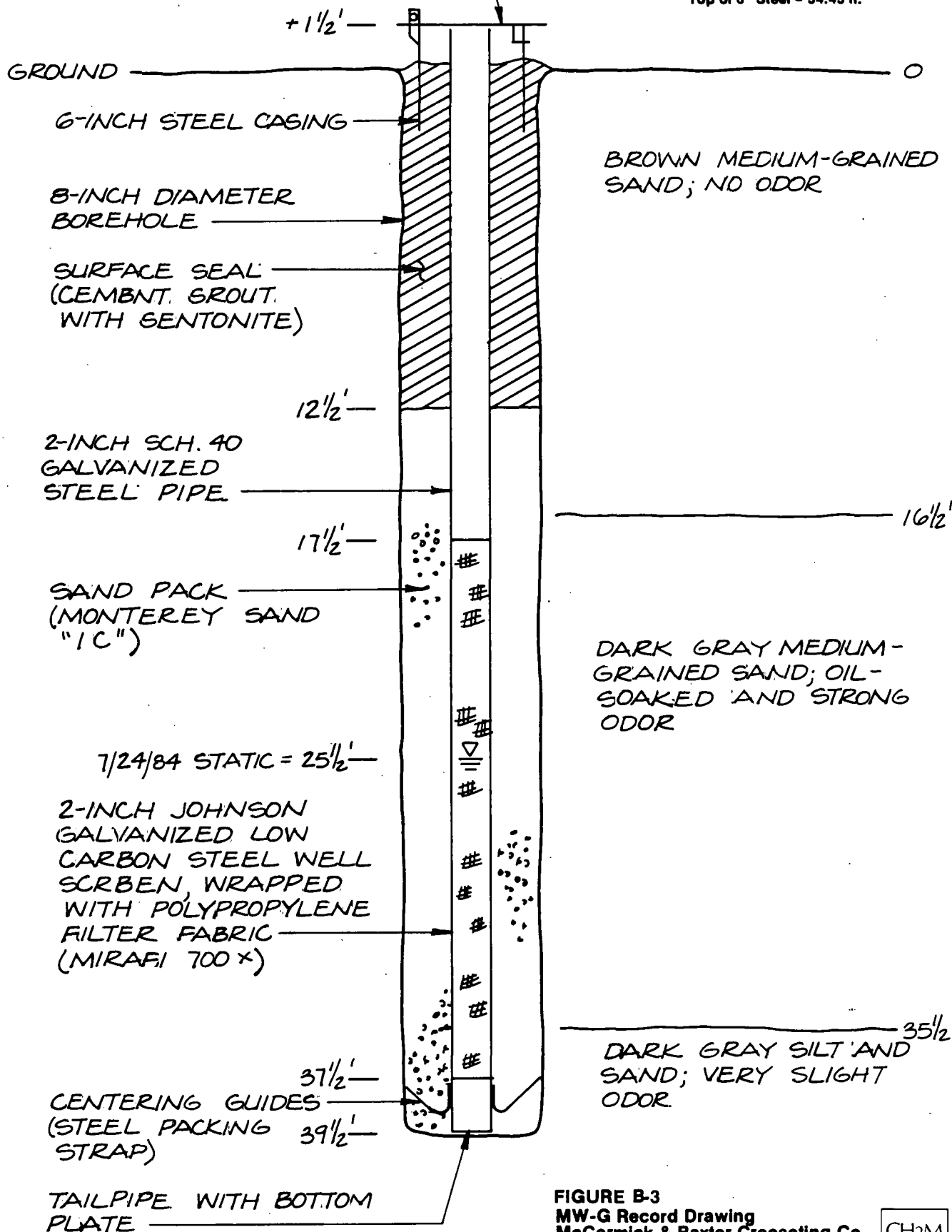


FIGURE B-3
MW-G Record Drawing
McCormick & Baxter Creosoting Co.
Portland, Oregon



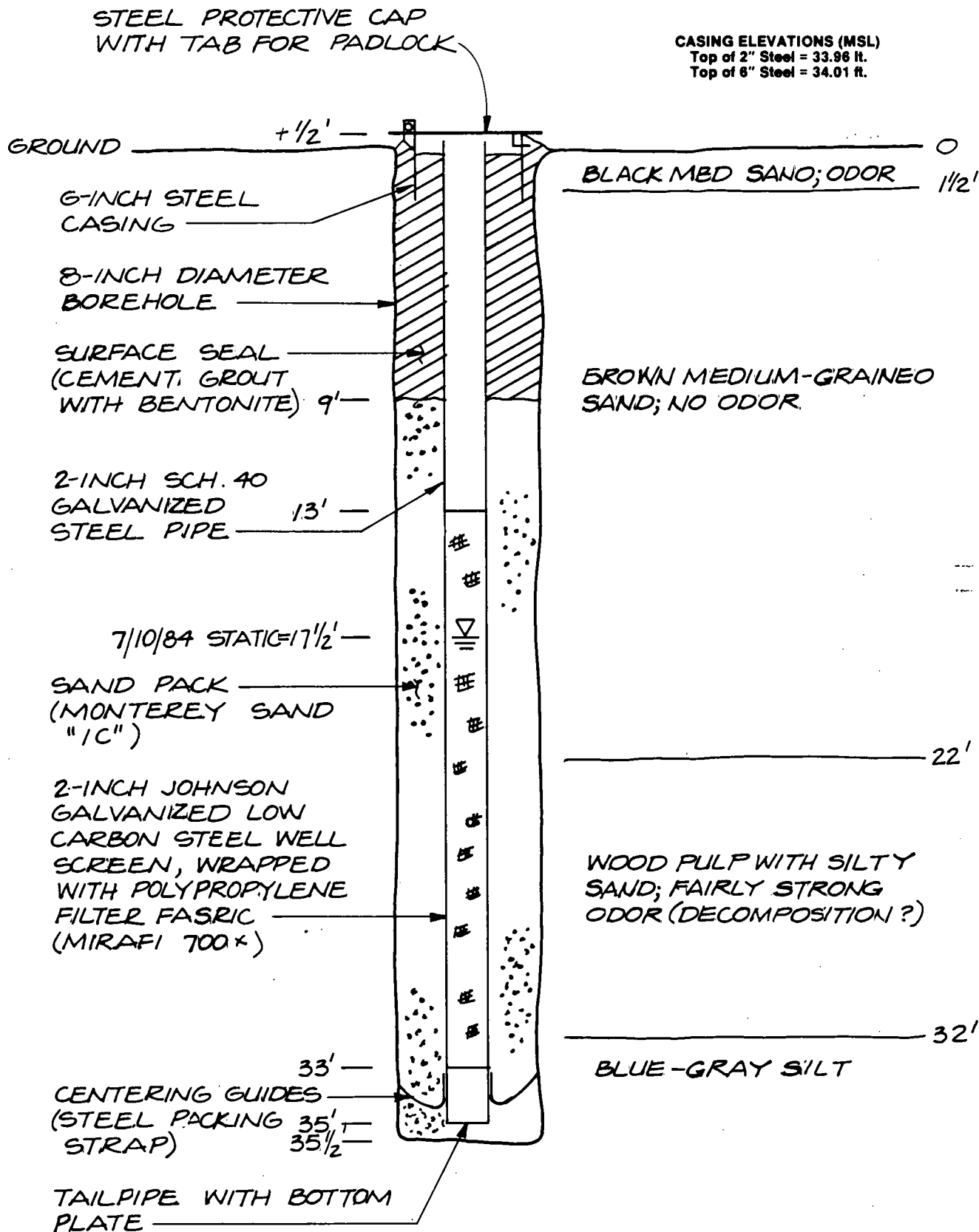


FIGURE B-4
MW-H Record Drawing
McCormick & Baxter Creosoting Co.
Portland, Oregon



STEEL PROTECTIVE CAP
WITH TAB FOR PADLOCK

CASING ELEVATIONS (MSL)
Top of 2" Steel = 32.73 ft.
Top of 6" Steel = 32.80 ft.

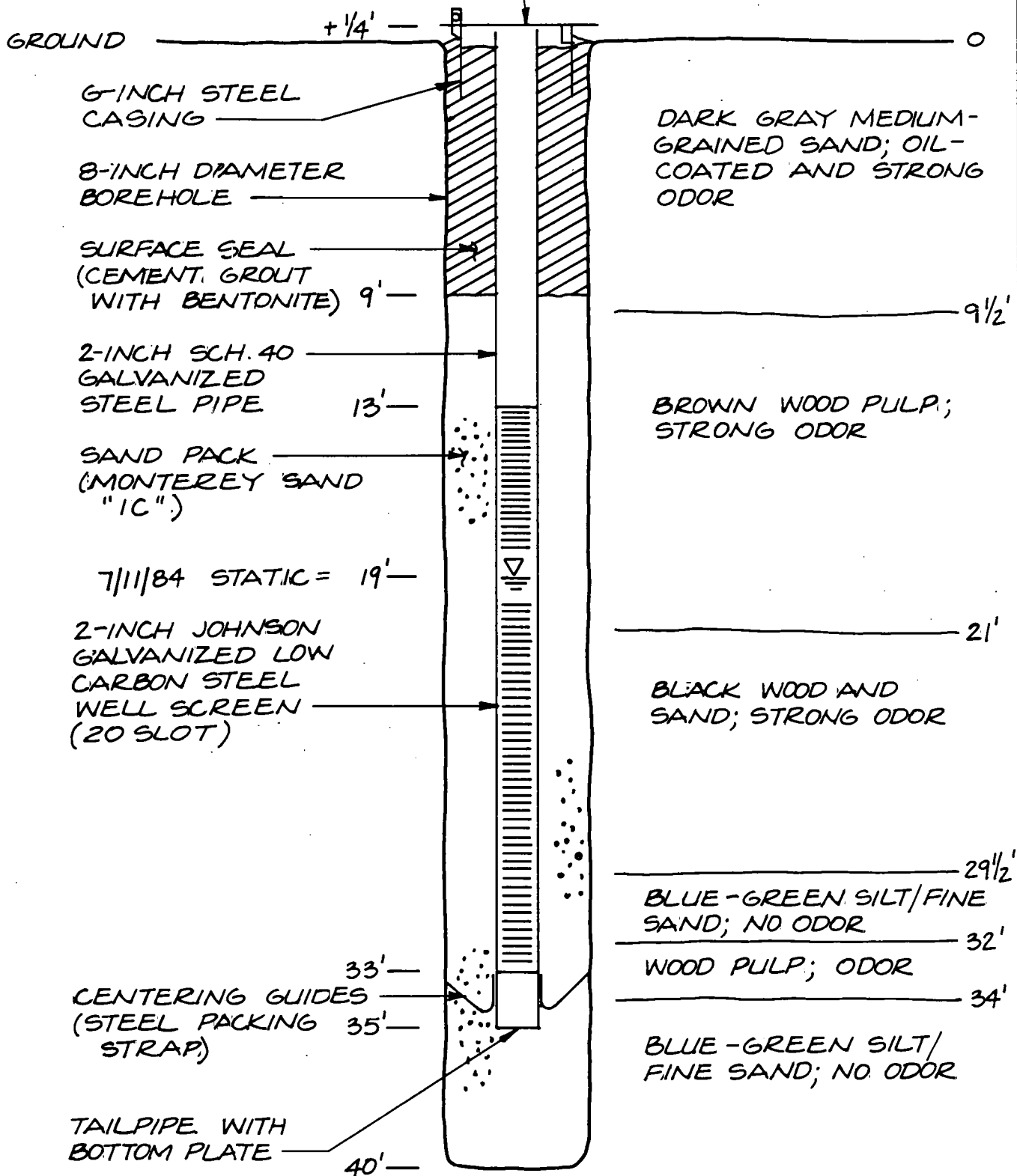


FIGURE B-5
MW-1 Record Drawing
McCormick & Baxter Creosoting Co.
Portland, Oregon



CASING ELEVATIONS (MSL)
Top of 2" Steel = 34.43 ft.
Top of 6" Steel = 34.59 ft.



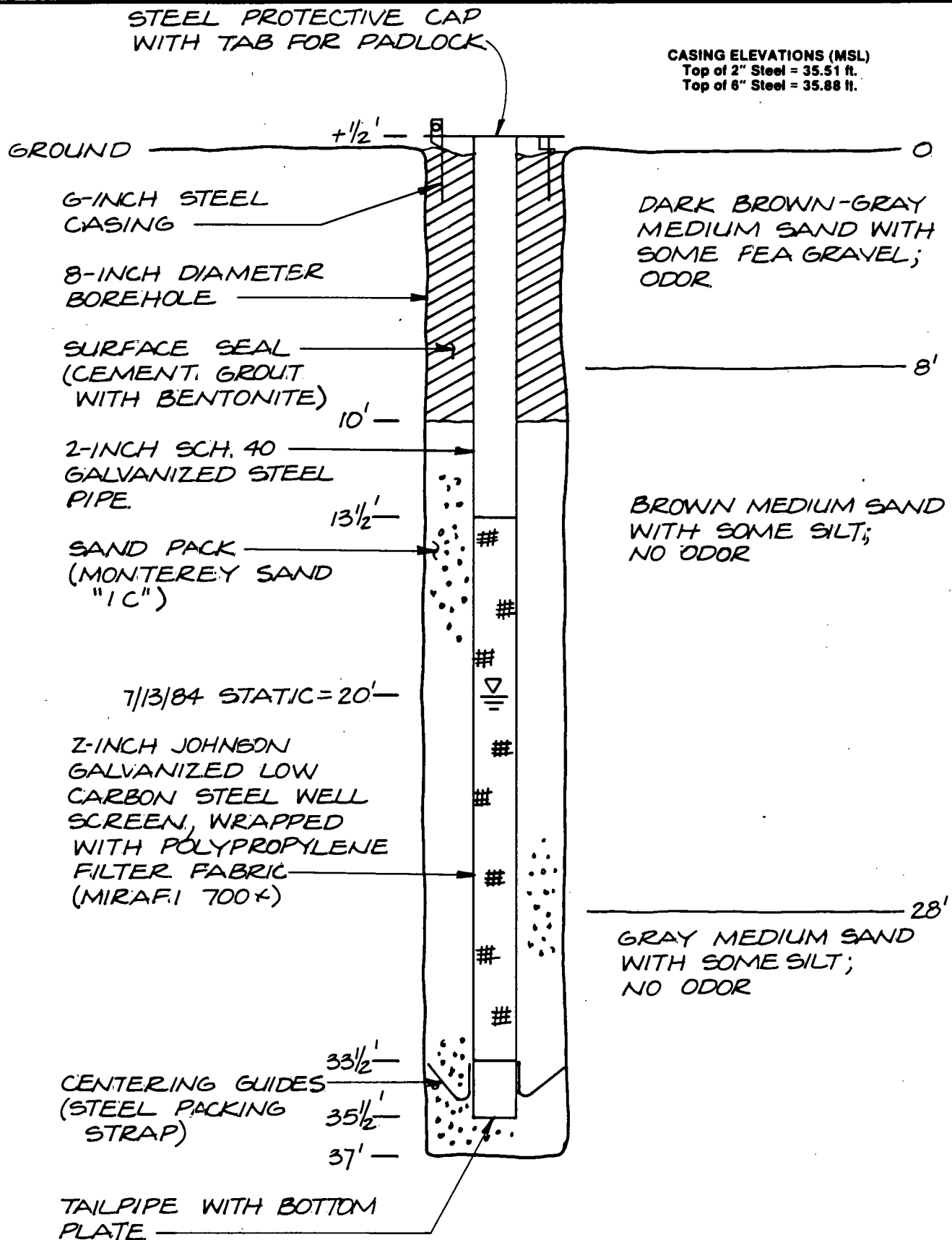


FIGURE B-7
MW-K Record Drawing
McCormick & Baxter Creosoting Co.
Portland, Oregon



STEEL PROTECTIVE CAP.
WITH TAB FOR PADLOCK

CASING ELEVATIONS (MSL)
Top of 2" Steel = 34.43 Ft.
Top of 6" Steel = 34.61 Ft.

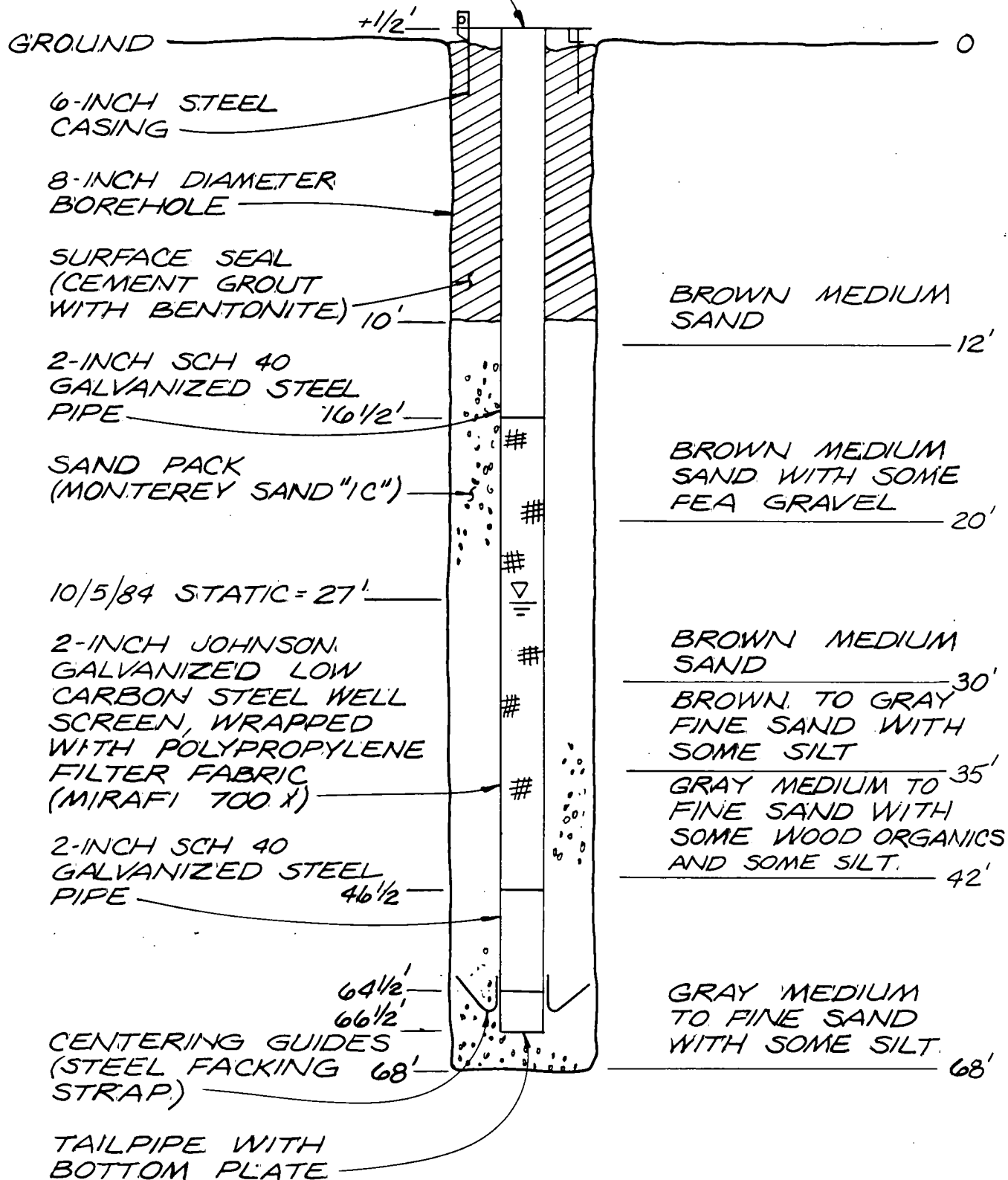


FIGURE B-8
MW-L Record Drawing
McCormick & Baxter Creosoting Co.
Portland, Oregon



STEEL PROTECTIVE CAP
WITH TAB FOR PADLOCK

CASING ELEVATIONS (MSL)
Top of 2" Steel = 35.08
Top of 6" Steel = 35.34

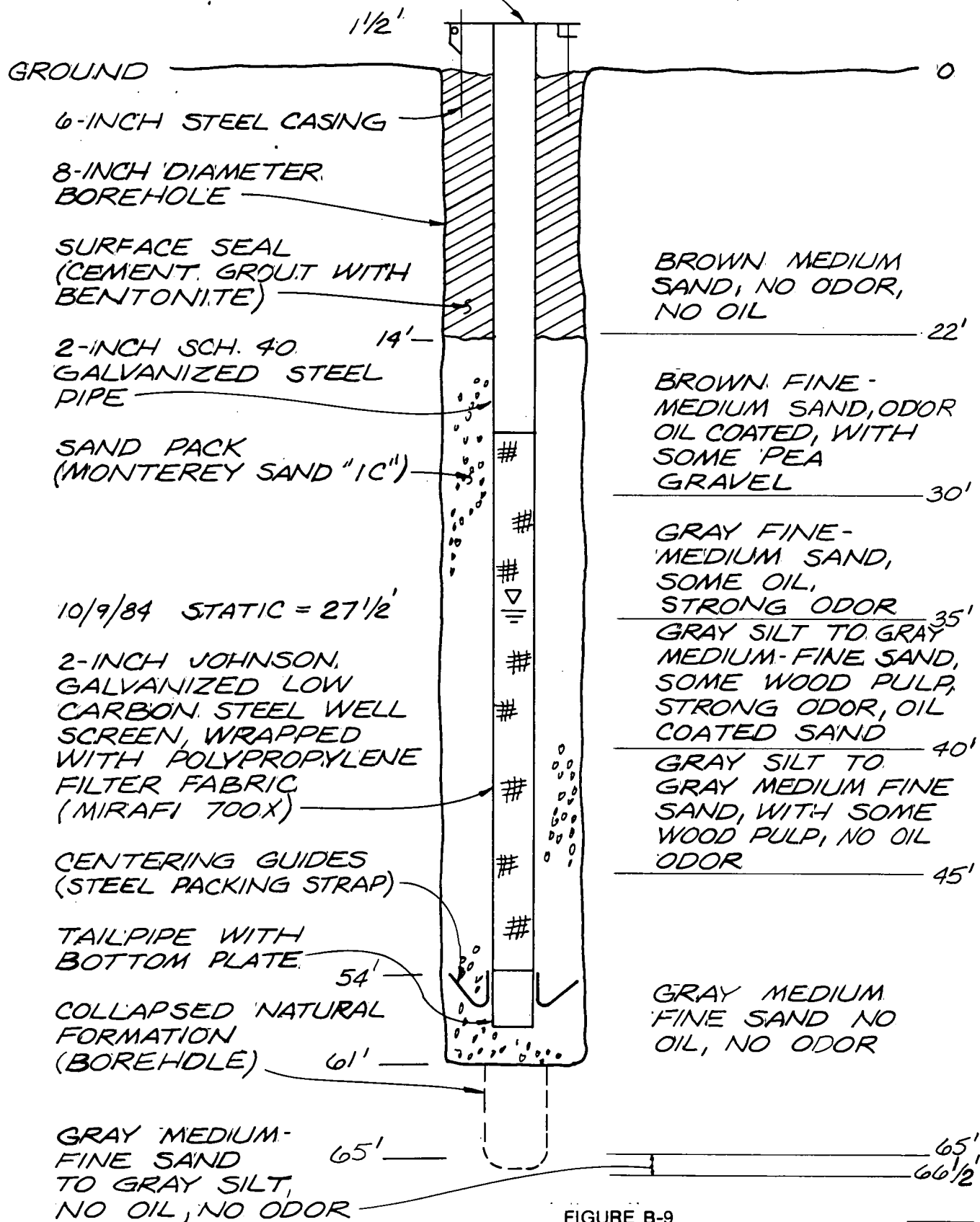


FIGURE B-9
MW-M Record Drawing
McCormick & Baxter Creosoting Co.
Portland, Oregon



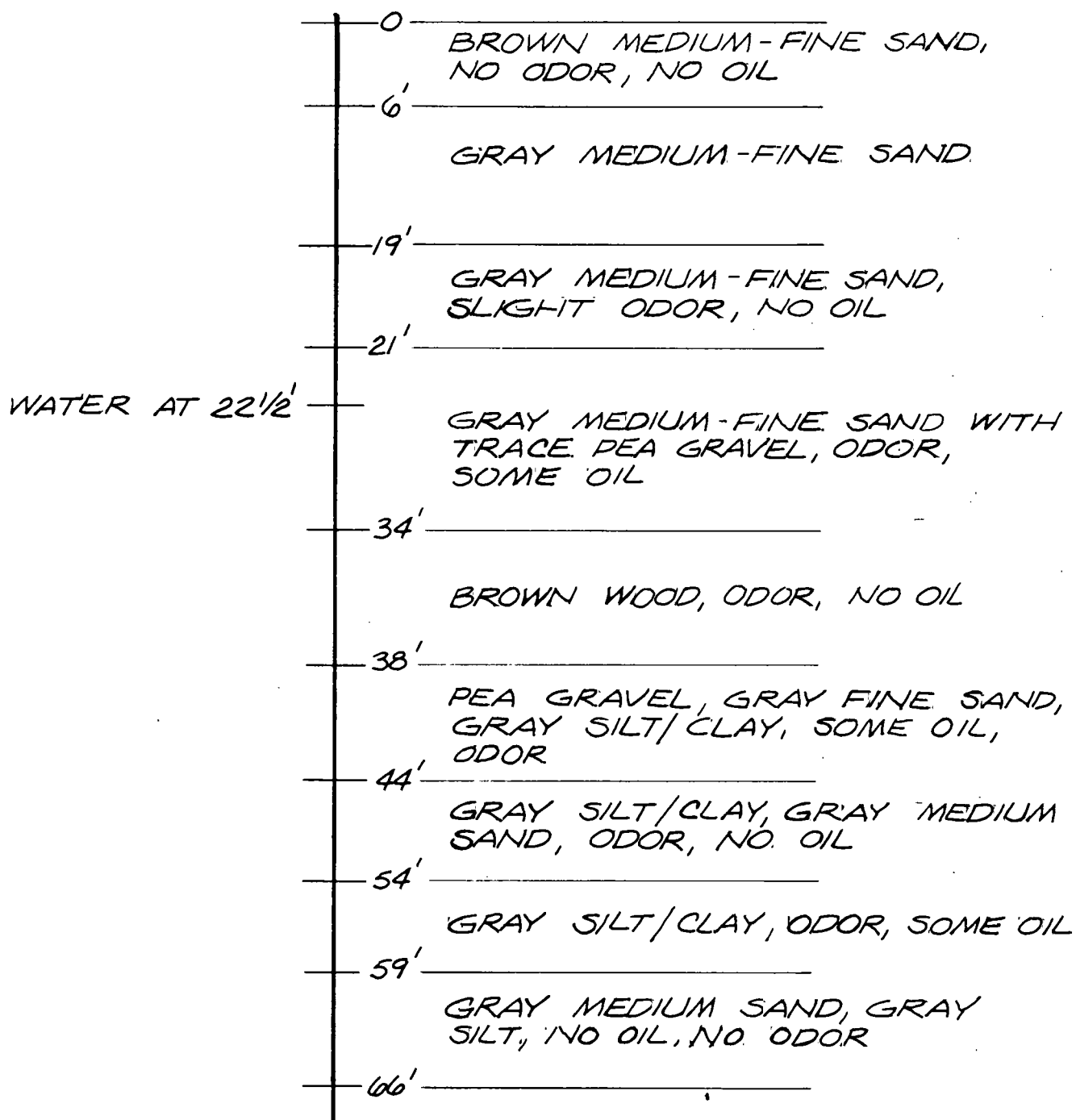


FIGURE B-10
Borehole 1
McCormick & Baxter Creosoting Co.
Portland, Oregon



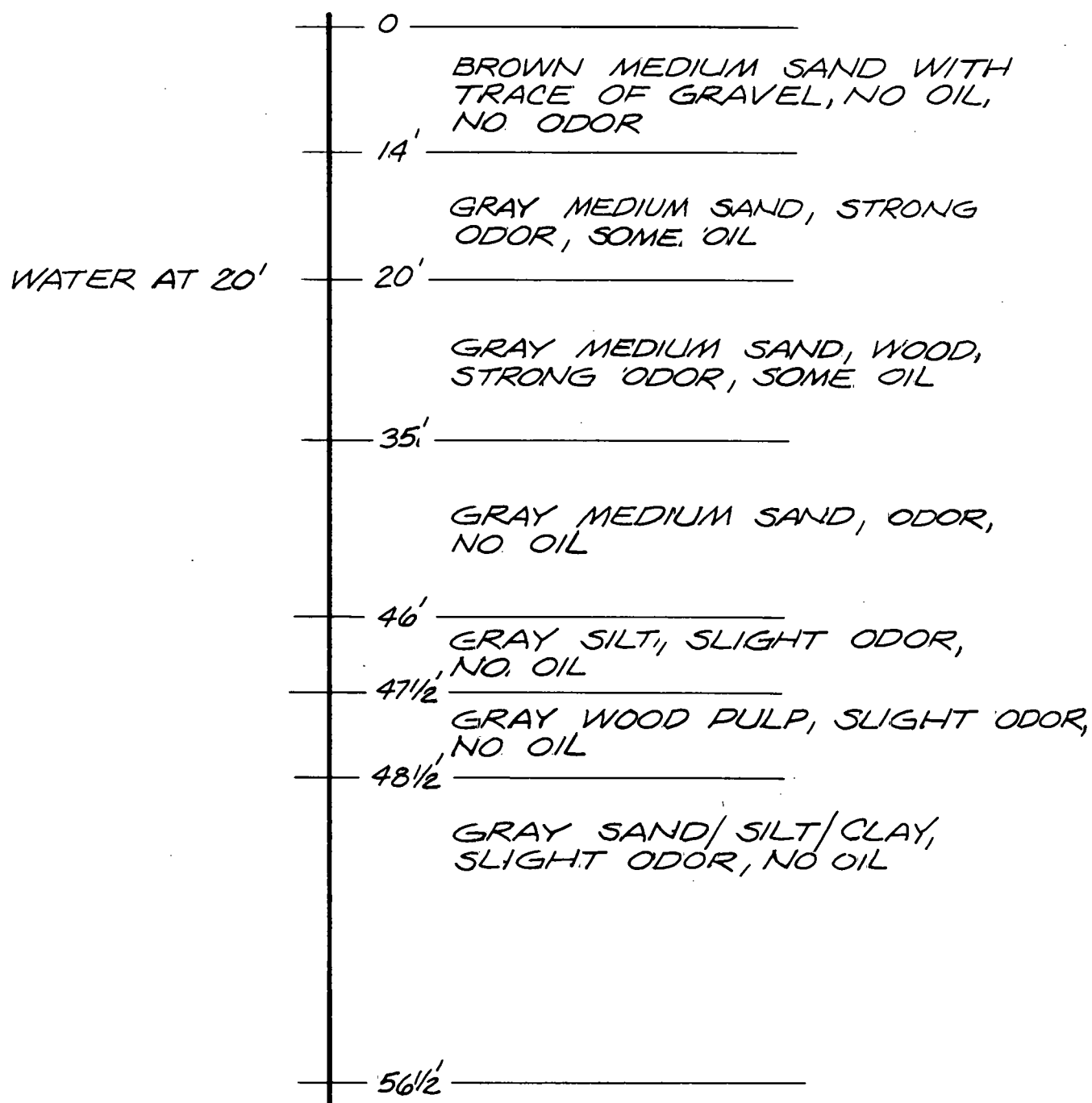


FIGURE B-11

Borehole 2
McCormick & Baxter Creosoting Co.
Portland, Oregon



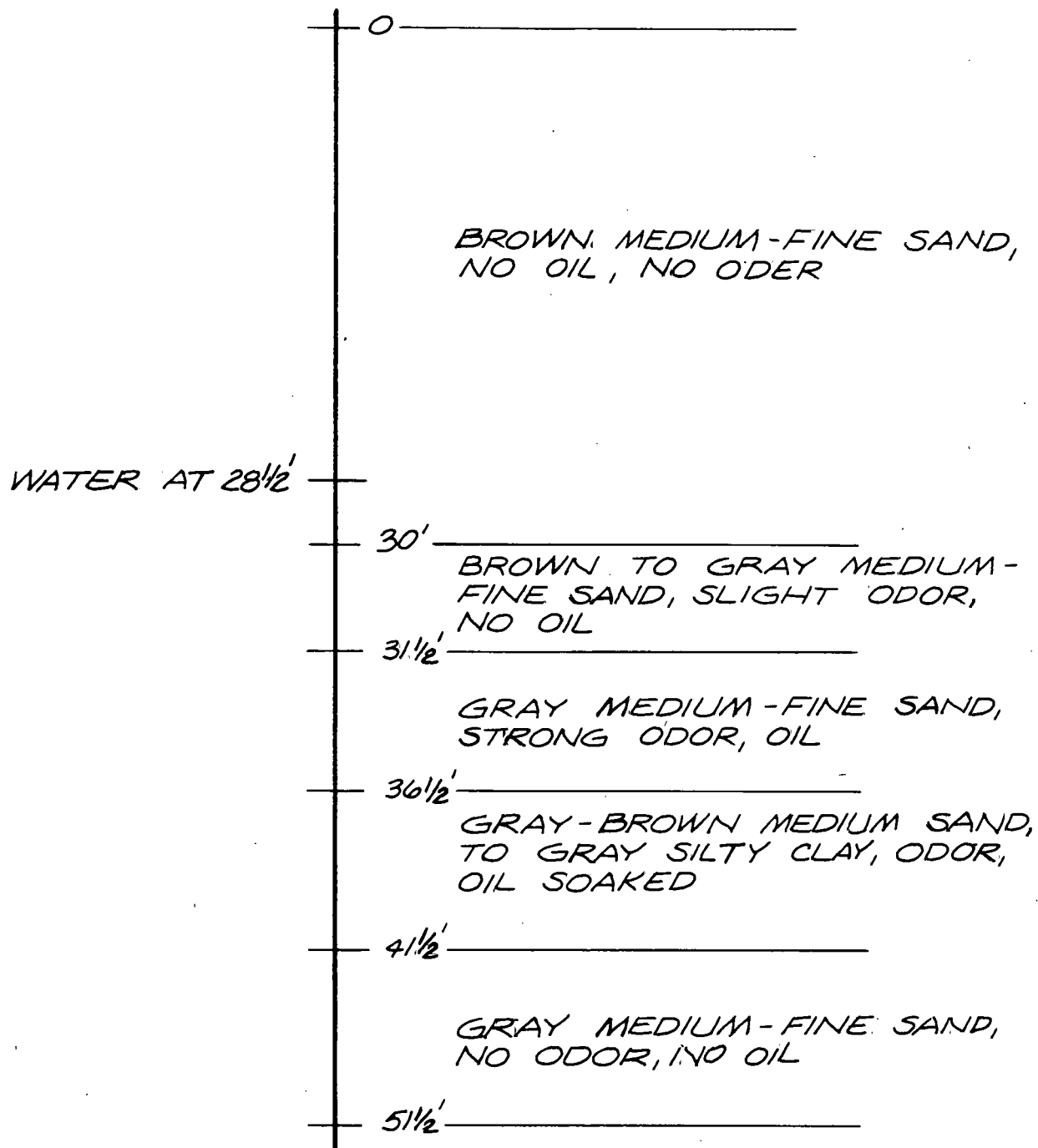


FIGURE B-12
Borehole 3
McCormick & Baxter Creosoting Co.
Portland, Oregon



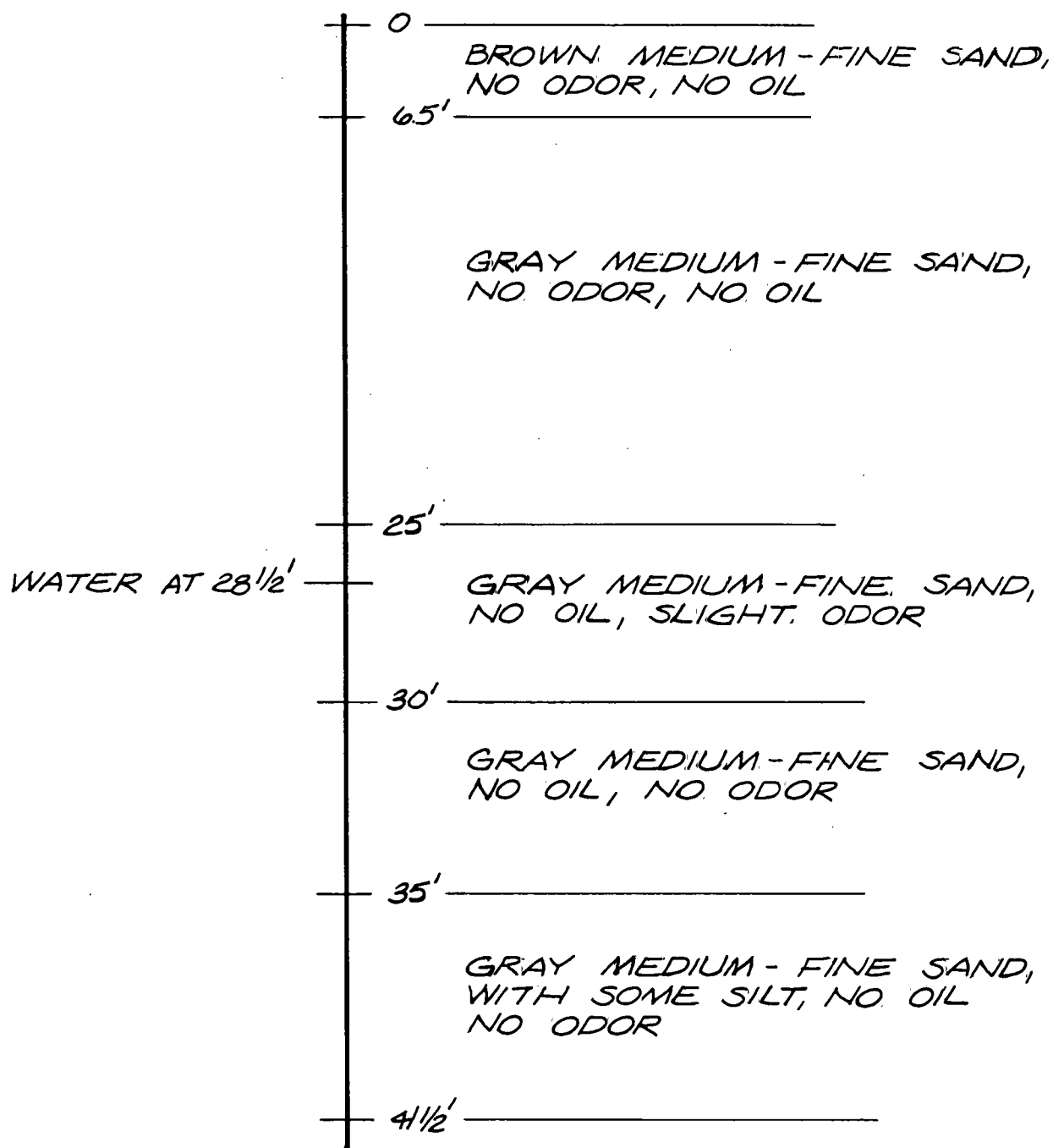


FIGURE B-13
Borehole 4
McCormick & Baxter Creosoting Co.
Portland, Oregon



APPENDIX C
LABORATORY RESULTS

SOIL QUALITY (Sheet 1)
in mg/kg unless specified otherwise

<u>Sample Point</u>	<u>Depth (feet)</u>	<u>Copper</u>	<u>Chromium</u>	<u>Arsenic</u>	<u>Oil and Grease</u>	<u>PAH's</u>	<u>Pentachlorophenol</u>
MW-A	0	24	16	<6	<0.1*	BMDL	BMDL
	5	15.3	14.3	6	<0.1*	BMDL	BMDL
	10	15.8	14.1	12	0.1*	BMDL	BMDL
	15	16.2	13.8	8	<0.1*	BMDL	BMDL
	20	23.1	17.9	13	<0.1*	BMDL	BMDL
	25	13.5	10.3	<4	<0.1*	BMDL	BMDL
MW-B	5	14.5	11.0	8	<0.1*	BMDL	BMDL
	10	15.8	12.6	12	<0.1*	BMDL	BMDL
	15	15.9	13.8	11	<0.1*	BMDL	BMDL
	20	1.5	1.9	<4	<0.1*	BMDL	BMDL
	25	12.6	13.2	7	<0.1*	BMDL	BMDL
MW-C	5	14.8	13.3	5	<0.1*	BMDL	1.4
	10	14.8	12.4	10	<0.1*	BMDL	0.3
	15	13.6	9.8	7	<0.1*	BMDL	0.5
W-D	5	18.8	14.0	16	<0.1*	BMDL	0.6
	10	15.0	12.6	10	<0.1*	BMDL	BMDL
	15	15.6	13.2	7	<0.1*	BMDL	BMDL
	20	16.8	13.8	10	<0.1*	BMDL	BMDL
	25	14.7	16.6	5	0.26*	90	2,400
	30	17.2	29.4	<4	2.04*	250	10,000

Source: Aqua Resources, Inc.

Notes: The data indicates absolute levels of individual constituents at specific onsite locations.
Exposure calculations are required to estimate potential offsite levels.
< means none detected, sensitivity as indicated.
BMDL means below minimum detection limit.
PAH detection limit 1 mg/kg.
Pentachlorophenol detection limit 0.1 mg/kg.
All results are based on dry soil weight.
* Units in percent

SOIL QUALITY (Sheet 2)
in mg/kg unless specified otherwise

Sample Point	Depth (feet)		Moisture (%)	Copper	Chromium	Arsenic	Oil and Grease	PAH's	Pentachlorophenol
MW-E	0-5	NA	--	--	--	--	--	--	--
	5-10	--	7.56	27.7	31.5	7.01	21,000	NA	280
	10-15	NA	--	--	--	--	--	--	--
	15-20	NA	--	--	--	--	--	--	--
	20-25	NA	--	--	--	--	--	--	--
	25-30	NA	--	--	--	--	--	--	--
	30-35	NA	--	--	--	--	--	--	--
	35-40	--	17.8	13.4	8.44	10.3	86	NA	0.740
	40-45	--	17.3	19.0	12.2	13.9	145	NA	0.081
	45-46	NA	--	--	--	--	--	--	--
MW-F	2-5	NA	--	--	--	--	--	--	--
	5-10	NA	--	--	--	--	--	--	--
	10-15	NA	--	--	--	--	--	--	--
	15-20	--	12.1	16.3	11.2	1.54	204	NA	0.027
	20-25	NA	--	--	--	--	--	--	--
	25-30	NA	--	--	--	--	--	--	--
	30-35	--	21.8	15.1	10.7	8.91	436	NA	0.068
	35-39	--	27.4	9.23	7.18	7.18	95 ^a	BMDL	<0.1 ^a
MW-G	2-5	NA	--	--	--	--	--	--	--
	5-10	NA	--	--	--	--	--	--	--
	10-15	--	6.69	13.5	9.03	3.24	296	NA	0.188
	15-20	--	19.4	17.8	36.0	3.27	17,400	NA	258
	20-25	NA	--	--	--	--	--	--	--
	25-30	NA	--	--	--	--	--	--	--
	30-35	NA	--	--	--	--	--	--	--
	35-38	NA	--	--	--	--	--	--	--
	38-39.5	--	25.3	16.7	12.8	2.11	438	NA	0.306
MW-H	0-5	NA	--	--	--	--	--	--	--
	5-10	--	7.29	14.1	10.3	16.9	445	NA	0.091
	10-15	NA	--	--	--	--	--	--	--
	15-20	NA	--	--	--	--	--	--	--
	20-25	--	49.5	19.5	14.9	14.5	10,000	NA	0.666
	25-30	NA	--	--	--	--	--	--	--
	30-35	--	31.65	15.5	16.1	10.6	99 ^a	BMDL	<0.1 ^a

Source: CH2M HILL

Notes: The data indicates absolute levels of individual constituents at specific onsite locations.
Exposure calculations are required to estimate potential offsite levels.
< means none detected, sensitivity as indicated.
NA means not analyzed, sample in storage.
BMDL means below minimum detection limit.
Creosote detection limit 5 mg/kg.
Pentachlorophenol detection limit 0.1 mg/kg.

^a Results are based on wet soil weight; all other results are based on dry soil weight.

SOIL QUALITY (Sheet 3)
in mg/kg unless specified otherwise

Sample Point	Depth (feet)		Moisture (%)	Copper	Chromium	Arsenic	Oil and Grease	PAH's	Pentachlorophenol
MW-I	0-5	NA	--	--	--	--	--	--	--
	5-10	--	14.9	14.6	9.26	4.49	5,840	NA	1.49
	10-15	NA	--	--	--	--	--	--	--
	15-20	NA	--	--	--	--	--	--	--
	20-25	NA	--	--	--	--	--	--	--
	25-30	NA	--	--	--	--	--	--	--
	30-35	--	30.8	30.5	25.0	19.8	1,600	NA	0.095
	35-40	--	33.7	29.9	21.3	1.97	1,700	NA	0.143
	40-41.5	NA	--	--	--	--	--	--	--
MW-J	0-5	NA	--	--	--	--	--	--	--
	5-10	--	11.0	16.1	12.0	26.6	1,150	NA	1,330
	10-15	NA	--	--	--	--	--	--	--
	15-20	--	18.0	13.9	9.86	27.9	1,040	NA	298
	20-25	NA	--	--	--	--	--	--	--
	25-30	NA	--	--	--	--	--	--	--
	30-35	--	19.8	7.96	5.55	5.38	111 ^a	BMDL	0.20 ^a
MW-K	0-5	NA	--	--	--	--	--	--	--
	5-10	--	9.3	12.9	9.68	2.99	383	NA	0.426
	10-15	NA	--	--	--	--	--	--	--
	15-20	--	15.1	16.3	11.7	1.74	909	NA	0.523
	20-25	NA	--	--	--	--	--	--	--
	25-30	--	14.9	11.3	4.47	4.03	67 ^a	BMDL	<0.1 ^a
	30-35	NA	--	--	--	--	--	--	--
MW-L	35-38.5	NA	--	--	--	--	--	--	--
	10-11.5	--	7.47	9.38	5.86	2.27	536 ^a	BMDL	<0.1 ^a
	25-26.5	--	22.07	8.51	6.30	8.57	477 ^a	BMDL	<0.1 ^a
	30-31.5	--	18.40	8.21	6.16	6.39	412 ^a	BMDL	0.37
	65-66.5	--	23.82	10.5	7.40	9.12	249 ^a	BMDL	<0.1 ^a

Source: CH2M HILL

Notes: The data indicates absolute levels of individual constituents parameters at specific onsite locations. Exposure calculations are required to estimate potential offsite levels.
< means none detected, sensitivity as indicated.

NA means not analyzed, sample in storage.

BMDL means below minimum detection limit.

Creosote detection limit 5 mg/kg.

Pentachlorophenol detection limit 0.1 mg/kg.

^a Results are based on wet soil weight; all other results are based on dry soil weight.

SOIL QUALITY (Sheet 4)
in mg/kg unless specified otherwise

Sample Point	Depth (feet)		Moisture (%)	Copper	Chromium	Arsenic	Oil and Grease	PAH's	Pentachlorophenol
MW-M	10-11.5	--	4.72	7.75	5.33	4.97	222 ^a	BMDL	<0.1 ^a
	25-26.5	--	24.12	8.04	5.94	7.02	308 ^a	BMDL	<0.163
	30-31.5	--	20.06	8.17	6.32	6.32	276 ^a	BMDL	1.30
	35-36.5	--	23.48	8.92	5.85	9.27	2,460 ^a	613	136
	40-41.5	--	22.31	12.8	8.34	9.59	146 ^a	BMDL	0.98
	65-66.5	--	23.87	11.2	7.34	7.10	393 ^a	BMDL	<0.1 ^a
BH-1	4-5.5	NA	--	--	--	--	--	--	--
	9-10.5	--	8.12	10.1	7.30	1.13	208 ^a	BMDL	<0.1 ^a
	14-15.5	NA	--	--	--	--	--	--	--
	19-20.5	NA	--	--	--	--	--	--	--
	24-25.5	--	13.76	9.55	0.568	0.334	720 ^a	2,740	7.07
	29-30.5	NA	--	--	--	--	--	--	--
	39-41.5	NA	--	--	--	--	--	--	--
	49-50.5	--	18.05	9.52	8.29	0.467	7,930 ^a	6,132	0.31
	54-55.5	NA	--	--	--	--	--	--	--
	59-60.5	--	20.78	8.85	5.99	2.56	60 ^a	BMDL	<0.1
BH-2	5-6.5	NA	--	--	--	--	--	--	--
	10-11.5	--	7.32	9.34	6.05	3.47	96 ^a	BMDL	<0.1 ^a
	15-16.5	--	20.61	8.36	5.68	0.368	224 ^a	1,198	80.4
	20-21.5	NA	--	--	--	--	--	--	--
	25-26.5	--	26.17	7.11	4.14	0.990	1,680 ^a	576	27.6
	30-31.5	NA	--	--	--	--	--	--	--
	40-41.5	NA	--	--	--	--	--	--	--
BH-3	55-56.5	--	32.17	21.7	15.3	4.19	164 ^a	BMDL	<0.1 ^a
	25-26.5	--	16.93	7.84	5.13	0.416	440 ^a	BMDL	<0.1 ^a
	35-36.5	--	29.17	6.73	4.73	6.94	2,490 ^a	6,722	1.162
	40-41.5	--	15.28	10.9	8.75	9.04	7,520 ^a	2,354	0.121

Source: CH2M HILL

Notes: The data indicates absolute levels of individual constituents at specific onsite locations.

Exposure calculations are required to estimate potential offsite levels.

< means none detected, sensitivity as indicated.

NA means not analyzed, sample in storage.

BMDL means below minimum detection limit.

Creosote detection limit 5 mg/kg.

Pentachlorophenol detection limit 0.1 mg/kg.

^a Results are based on wet soil weight; all other results are based on dry soil weight.

Subject: Analysis of six liquid and four soil samples from McCormick & Baxter, Portland, Oregon. The samples were received and assigned reference Nos. 1924-1933.

Parameter as mg/L	Liquid Samples					
	#1	#2	#3	#4	#5	#6
Arsenic, As	0.023	0.066	0.033	0.450	<0.005	1.12
Chromium, total as Cr	0.21	0.06	0.05	6.94	<0.05	0.62
Conductivity	370	760	260	620	340	148
Copper, Cu	0.44	0.10	0.09	1.30	0.03	2.97
Nitrogen forms, as N						
Ammonia	0.04	0.10	<0.02	<0.02	<0.02	<0.02
Nitrate	2.16	0.119	0.420	<0.05	2.60	0.560
Oil & Grease	1	<1	4	6890	<1	121
pH	6.9	6.8	7.5	6.8	7.6	6.6
Total Dissolved Solids	249	609	315	512	307	381
Pentachlorophenol, µg/ml	<0.2	<0.2	<0.2	25.4	<0.2	1.9

Sample Descriptions

1. MW-A, 1-17-84, 1125, MBR, KWS
2. MW-B, 1-18-84, 0856, MBR
3. MW-C, 1-17-84, 1345, MBR, KWS
4. MW-D, 1-17-84, 1500, MBR
5. Process Well #1, 1-17-84, 1040, MBR
6. Storm Water Outfall, 1-17-84, 1410, MBR

< Indicates "less than."

All tests are performed in accordance with current Environmental Protection Agency guidelines as published in the Federal Register.

The information shown on this sheet is test data only and no interpretation is intended or implied.

Samples will be retained 30 days unless otherwise requested.

Reported by: Randi J. Gant
Randi J. Gant

sm/CVLAB/054-1



Engineers
Planners
Economists
Scientists

Environmental Laboratory

Date: September 19, 1984

Project No.: P17774.A0

Subject: Analysis of ten water samples from McCormick & Baxter. The samples were received August 17, 1984, and assigned reference Nos. 4320-4329.

Parameter as mg/L	Arsenic, As	Chromium, Cr Total	Conductivity μ mhos/cm	Copper, Cu	pH	Pentachloro- phenols, ppb	Total Dissolved Solids	TOC
MW-A	0.073	0.082	610	0.17	6.3	0.9	492	32.0
MW-C	0.023	0.040	250	<0.02	7.1	1.6	340	24.5
MW-D	0.077	1.93	640	0.42	6.6	110,000	592	265
MW-E	0.041	0.079	470	0.05	6.5	259	506	32.2
MW-F	0.017	0.006	470	<0.02	6.4	1,369	418	10.8
MW-G	0.062	1.01	500	0.18	6.5	24,200	444	592
MW-H	<0.005	0.011	740	<0.02	6.2	6.5	548	79.5
MW-I	0.069	0.172	670	0.14	6.3	91,700	614	169
MW-J	0.020	0.012	1130	0.04	6.4	9,008	960	16.2
MW-K	0.017	0.008	450	<0.02	6.7	88.5	450	7.10

TOC: Total Organic Carbon
< Indicates "less than"

All tests are performed in accordance with current Environmental Protection Agency guidelines as published in the Federal Register.

The information shown on this sheet is test data only and no interpretation is intended or implied.

Samples will be retained 30 days unless otherwise requested.

Reported by:


Randi J. Gant

dmk/CVLAB/050-4



Engineers
Planners
Economists
Scientists

Environmental Laboratory

Date: December 7, 1984

Project: P17774.A0

Page 1 of 2

Subject: Analysis of water samples from McCormick and Baxter.
The samples were received September 26 & 27, 1984 and
assigned reference nos. 5150-5159.

<u>Parameter as mg/L</u>	<u>MW-A</u>	<u>MW-C</u>	<u>MW-D</u>	<u>MW-E</u>	<u>MW-F</u>
pH	6.6	7.3	7.0	6.7	6.6
Conductivity micromhos/cm	600	420	43	79	610
Total Dissolved Solids	426	370	552	388	334
Arsenic, As	0.030	0.033	0.078	0.310	0.087
Chromium, Total Cr	0.040	0.020	3.45	0.45	<0.005
Copper, Cu	0.04	0.03	0.33	0.42	<0.02
Total Organic Carbon	31.8	21.3	58.7	56.4	23.0
Pentachlorophenol	<0.01	<0.01	19.1	2.66	1.37



Engineers
Planners
Economists
Scientists

Environmental Laboratory

Date: December 7, 1984

Project: P17774.A0

Page 2 of 2

Parameter as mg/L	MW-G	MW-H	MW-I	MW-J	MW-K
pH	7.0	6.4	6.5	5.5	7.1
Conductivity micromhos/cm	46	725	13.8	1,460	620
Total Dissolved Solids	488	464	572	948	392
Arsenic, As	0.240	0.010	0.041	0.024	0.026
Chromium, Total Cr	9.77	0.020	0.032	0.016	0.009
Copper, Cu	0.29	0.02	<0.02	<0.02	<0.02
Total Organic Carbon	27.6 175	27.7	47.2	13.6	19.6
Pentachlorophenol	839	0.01	116	1.49	<0.01

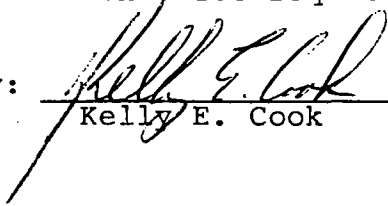
< Indicates "less than"

All tests are performed in accordance with current Environmental Protection Agency guidelines as published in the Federal Register.

The information shown on this sheet is test data only and no interpretation is intended or implied.

Samples will be retained 30 days unless otherwise requested.

Reported by:


Kelly E. Cook

1kg/CVLAB/127

APPENDIX D
DEGRADATION OF
WOOD TREATMENT WASTES

Appendix D
DEGRADATION OF WOOD TREATMENT WASTES

A large data base is available on the biological and chemical breakdown of creosote and pentachlorophenol in soil and in water. The major emphasis of this appendix is the description of the chemical and biological processes in soil which lead to decomposition of these chemicals, as well as the nondecomposition processes such as volatilization and adsorption.

Technical grade pentachlorophenol used for treatment of wood typically contains 85 to 90 percent pentachlorophenol. The remaining materials in technical grade pentachlorophenol are 2,3,4,6-tetrachlorophenol (4 to 8 percent), chlorinated phenoxyphenols (2 to 6 percent), and dioxins (less than 0.1 percent). There are a relatively large number of different chlorinated phenoxyphenols in technical grade pentachlorophenol.

The dioxin which makes up over 90 percent of this fraction is octachlorodibenzo-p-dioxin (OCDD). There are also traces of the hepta and hexa isomers. None of the most toxic 2,3,7,8-tetrachlorodibenzo-p-dioxin isomer has been found in pentachlorophenol produced in the United States.

Creosote is an even more complex mixture of chemicals produced from coal by destructive distillation. The major components are polynuclear aromatic hydrocarbons (PAH's). The concentration of some of the major components found in creosote are shown in Table D-1.

Table D-1
MAJOR COMPONENTS OF CREOSOTE (1)

<u>Creosote Component</u>	<u>% Whole Creosote</u>
Naphthalene	17.0
2-Methylnaphthalene	6.5
1-Methylnaphthalene	3.5
Biphenyl	1.9
Acenaphthylene	0.5
Acenaphthene	7.8
Dibenzofuran	5.2
Fluorene	6.0
Phenanthrene	19.4
Anthracene	2.52
Carbazole	5.1
Fluoranthene	11.8
Pyrene	8.4
1,2-Benzathracene/Chrysene	4.2

DEGRADATION IN SOIL

In general, when wood-treating chemicals are put on soil several processes can occur. The sample can undergo adsorption, volatilization, or decomposition in the soil. The relative occurrence of each of these processes depends on many factors, including the physical and chemical properties of the chemical, the physical and chemical properties of the soil, and other environmental influences. Most soils already contain an initial supply of micro-organisms which can seed the biodegradation of organic constituents.

ADSORPTION

Hilton and Yuen (1963) compared soil adsorption of penta to the soil adsorption of a number of substituted urea herbicides. They found that the adsorption of penta was the highest of all compounds studied. Excessive levels of application provided little improvement. This observation is consistent with steep slopes of the adsorption isotherms found for penta.

Choi and Aomine (1972, 1974, 1974a) studied interaction of penta and soil in detail. Adsorption and/or precipitation of penta occurred to some extent on all soils tested. Choi and Aomine (1974) concluded in a study of 13 soils that adsorption of penta primarily depended on the pH of the system. The more acid the soil, the more complete was the "apparent adsorption" of penta. Different mechanisms of adsorption dominate at different pH values. In acid clays "apparent adsorption" involved the adsorption on colloids, and precipitation in the micelle and in the external liquid phase. Organic matter content of soils is important to adsorption of penta at all pH values. Humus containing soil always adsorbs more penta than soil treated with H_2O_2 to remove organic matter. Later investigations led to the conclusions that adsorption of penta by humus is important when the concentration is low, but at higher concentrations the inorganic fraction increases in importance.

Three of four allophanic soils showed a significant increase in penta adsorption at higher temperatures, while the fourth soil showed a decrease (Choi and Aomine, 1974a). The difference between the three soils and the fourth soil could be explained by assuming that andosols chiefly adsorb penta as anions, whereas the major factor influencing penta adsorption by the fourth soil, showing a decrease with increasing temperature, is a Van der Waals force. Decreasing the concentration of chlorides or sulfate ions also increases the adsorption of penta to soil. These results indicate the occurrence of competition between inorganic anions and penta anions for adsorption sites on the soil colloid.

The persistence of penta in soil depends on a number of environmental factors. Young and Carroll (1951) noted that penta degradation was optimum when the moisture content of soil was near saturation. Kuwatsuka and Igarashi (1975) reported that the degradation of penta is faster under flooded conditions than under upland conditions. Loustalot and Ferrer (1950) found that penta was relatively stable in air-dried soils, persisted for 2 months in soil of medium moisture content, and for one month in water-saturated soil.

Soil composition has a great effect on the persistence of penta. It persisted longer in heavy clay than in sandy or sandy clay soils (Loustalot and Ferrer, 1950). An extensive study of the soil variables affecting the rate of degradation of 100 ppm penta was carried out by Kuwatsuka and Igarashi (1975). The rate was correlated with clay mineral composition, free iron content, phosphate adsorption coefficients, and cation exchange capacity of the soil, while the greatest effect was the correlation with organic matter. Little or no correlation could be found with soil texture, clay content, degree of base saturation, soil pH, and available phosphorus.

DECOMPOSITION

Three major types of decomposition reactions occur in soil--photochemical, chemical, and microbiological. The photochemical process is initiated by ultraviolet radiation from sunlight. Both pentachlorophenol and creosote are degraded by sunlight and due to lack of light penetration in soil, this reaction is more important in water contaminated with these materials than in soil. The photodegradation of OCDD was reported as being rapid in the presence of oil and sunlight, without the formation of TCDD (Arsenault 1976).

Chemical decomposition in soil, such as air oxidation or hydrolysis of weak bonds, is not an important reaction with penta and creosote since they do not have any groups that are easily oxidized or hydrolyzed.

BIOLOGICAL DECOMPOSITION

With both creosote and pentachlorophenol, the major process occurring in soil is microbiological decomposition and there have been a large number of studies on the breakdown in soil.

Penta decays more rapidly when the ambient temperature approaches the optimum value for microbiological activity (Young and Carroll, 1951). Ide et al. (1972) found no decay in sterilized soil samples. The positive correlation between organic matter content of soil and penta degradation also suggests that microorganisms play an important role (Kuwatsuka and Igarashe, 1975; and Young and Carroll, 1951). Kuwatsuka

and Igarashi (1975) studied degradation of penta in soils collected from flooded and upland areas. Upland soils degraded penta more rapidly in the laboratory when studied in the aerated condition, while soils obtained from flood conditions degraded penta more rapidly when tested in the flooded stage. Thus, penta degrading microorganisms present in the soil survived the transfer to the laboratory and were most active when placed in an environment to which they were adapted.

A summary of the literature values for the persistence of penta in soil is present in Table D-2. The time required for 90- to 100-percent decomposition ranged between 21 days and 5 years. The 5-year value obtained by Hetrick (1952) was from dry soil sealed in a jar and probably does not represent a realistic evaluation of the environmental half-life. Thus, penta can be considered to be degradable under most conditions, and to have a half-life of well less than 9 months in low and moderate concentrations in soil.

Numerous degradation routes have been isolated for penta-treated soil by Ide (1972), Kuwatsuka (1975), and Williams (1959). The route can be summarized as a reversible methylation reaction to form pentachloroanisole. The main route for decomposition is through dechlorination leading to a series of partial dechlorinated products, such as 2,3,5,6-tetrachlorophenol, which then undergo an oxidation step to form hydroquinones or catechols, which then undergo ring cleavage, ultimately forming methane, CO_2 , and inorganic chloride ion.

Recently, Murthy et al. (1977) examined the degradation of labelled ^{14}C penta in both aerobic and anaerobic moist soil. Losses by volatilization accounted for only 0.5 percent of the penta added and no $^{14}\text{CO}_2$ was detected. Gas chromatographic analysis of the soil extract showed the presence of the methyl ether of penta (0.7 percent). Progressively less chlorinated phenols such as 2,3,5,6- and 2,3,4,5-tetrachlorophenols and 2,3,5-trichlorophenol were identified as degradation products following methylation. Total ^{14}C recoveries were about 95 percent. Similar results were obtained in aerobic soils with regard to product formation. However, the principal product was the methyl ether of penta or pentachloroanisole. The reactions involved in the degradation of these compounds are reductive in anaerobic soils and both reductive and oxidative in aerobic soils. Completion of the penta decomposition process requires an oxidation step, and therefore is favored in aerobic soils.

Table D-2
DECOMPOSITION OF PENTA IN SOIL

Degradation Parameter	Soil Type	Special Conditions	Time	Reference
90% degradation	Arable layer in rice fields (11 soils)	60% water 25% water	Approx. 50 days Approx. 30 days	Kuatsuka and Igarashi, 1975
	Forest red-yellow soil sublayer	60% water 250% water	No degradation in 50 days	
90% degradation	Wooster silt loam	7.5 kg/ha penta, optimum condi- tions for micro- bial growth	Approx. 22 days	Young and Carroll, 1951
Complete	Dry soil in sealed jar	--	>5 years	Hetrick, 1952
Effect on growth of corn and cucumbers	Fertile sandy loam	Air-dried	>2 months	Loustalot and Ferrer, 1950
		Medium water	2 months	
		Water saturated	1 month	
90% degradation	Mature paddy soil	Low organic content	1 month	Ide et al., 1972
Complete degradation	Dunkirk silt loam	Aerated, aqueous soil suspension	Approx. 72 days	Alexander and Aleem, 1961
Complete degradation	Paddy soil	Soil perfusion	21 days	Watanabe, 1973
--	Warm, moist soil	--	>12 months	Bevenue and Beckman, 1967
98% degradation	Permeable soil	Composted with sludge from wood- treating plant	205 days	Arsenault, 1976

Chu and Kirsch (1972) isolated a bacterial culture by continuous flow enrichment that was capable of metabolizing penta as a sole source of organic carbon. Kirsch and Etzel (1973) derived a microbial population capable of rapid penta degradation from a soil sample obtained on the grounds of a wood products manufacturer. When fully acclimated, the populations were dosed with 100 mg/liter penta and 68 percent of the penta was degraded in 24 hours. The cultures were most effective when the penta was the sole source of carbon.

Watanabe (1973) reported penta degradation in soil samples subjected to 40 mg/liter penta. Bacteria isolates capable of penta decomposition were derived from a soil perfusion enrichment culture. Degradation and complete dechlorination occurred after 2 to 3 weeks of incubation. The bacterium were characterized as Pseudomonas sp. Aspergillus sp. and Trichoderma (Cserjesi, 1973) were also identified in the formation of pentachloroanisole by methylation. A soil bacterium isolated by Suzuki and Nose (1971) was capable of degrading penta. The major metabolite was pentachloroanisole and dimethyl ether; a minor metabolite was tetrachloro-hydroquinone.

It is clear that bacteria and fungi capable of degrading penta exist in the environment. In most cases where rapid degradation of penta by microorganisms has been demonstrated, the source of inoculum was from areas where penta had been used for a long time, such as around telephone poles or at wood treating plants.

Regardless of where the soil is obtained, the soil bacterial population capable of degrading pentachlorophenol can be increased by acclimating the soil to ever-increasing amounts of pentachlorophenol. McGinnis (1984) collected samples of soil from around pentachlorophenol-treated telephone poles; pentachlorophenol was added daily and the rate of degradation was determined. The initial half-life of pentachlorophenol, or the time for half the pentachlorophenol to disappear, was approximately 6 days. After one year, the half-life had decreased to 21 hours. As the bacterial population increased, larger amounts of pentachlorophenol were added without harmful effects. Initially, approximately one mg of pentachlorophenol was added to 40 g of soil each day. At the conclusion of the experiment (9 months), 90 mg of pentachlorophenol was being added to the soil every third day. The products were mainly methane, CO₂, and inorganic chloride ion. The only organic compound found in trace quantities was an isomer of tetrachlorophenol. Currently, the Mississippi Forest Products Laboratory is working on determining the rates of breakdown of some of the minor components found in technical grade pentachlorophenol, including OCDD and the chlorinated phenoxyphenols.

There has been less work on the soil degradation of creosote as compared to pentachlorophenol. However, the major route of degradation of creosote in soil is also microbiological degradation. Although PAH's found in creosote are susceptible to photochemical degradation, this reaction can only occur at the surface of the soil where sunlight can interact with the PAH's. The microbiological degradation in soil is mainly an aerobic process.

Dust and Thompson (1973) monitored total phenol content of water collected at various soil depths following irrigation of land with untreated creosote wastewater applied at the rate of 3,500 gallons/acre/day. Removal of phenols equaled or exceeded 99 percent at all soil depths within the range of one to 4 feet. Seasonal variations in removal efficiencies were negligible. Similar results have been reported by Fisher (1971). Satisfactory removal of phenols from creosote wastewater has also been achieved by trickling filters and activated-sludge units (EPA, 1976).

Lee, et al. (1978) found that the concentration of seven polynuclear aromatic hydrocarbons--including naphthalene, anthracene, fluoranthene, benz(a)anthracene, and benzo(a)pyrene--resulting from a controlled oil spill decreased exponentially from 74.4 to <0.2 microgram/liter after 10 days. The value decreased further to below the level of detection by the 17th day. The higher molecular weight compounds, particularly benzo(a)-pyrene and benzo(a)anthracene, were susceptible to photooxidation, with up to half of the former chemical being photooxidized. The remainder apparently became incorporated in bottom sediments. Microbial degradation of the naphthalene occurred at the rate of 5 percent per day.

Losses of liquid creosote from wood in terrestrial service are generally regarded to have no adverse effects on the environment. Creosote lost by exudation apparently does not migrate more than a few inches into the soil and is rapidly biodegraded. Indeed, in a study conducted at Mississippi State University (1975) on the movement of preservatives radially and vertically from treated poles, none of the major components of creosote was ever isolated from soil samples collected to a depth of 6 inches within the range of 2 to 24 inches from the pole. It was assumed that those components which entered the soil during the 5-year duration of the study were oxidized by soil microorganisms.

A study by Dust and Thompson (1973), while not providing definitive data on PAH reductions achieved by soil irrigation or creosote wastewater, showed a very high removal efficiency for phenols and other organic constituents. Percolation of wastewater through soil results in a reduction in chemical oxygen demand (COD) of 94.9, 95.3, and 97.4 percent for

depths of 1, 2, and 4 feet. Comparable reductions for total phenols were, in order, 98.9, 99.2, and 99.6 percent. Comparable reductions for total phenols were, in order, 98.9, 99.2, and 99.6. Removal efficiency was only mildly affected by seasonal changes.

Recent work shows that the rate of the microbiological reaction is related to the number of fused rings (Table D-3) in a molecule. The relative rate constant for microbiological decomposition generally decreases by a factor of 6-10 for each additional fused ring. It has been proposed that the rate differences are related to the decreasing water solubility of the larger PAH's.

Another important factor is the source of the soil. Soil that has been exposed to PAH's for long periods of time has a much higher rate of microbial activity toward PAH's (Table D-4). This is apparently due to the higher concentration in these types of soils of bacteria that are capable of utilizing PAH's as a source of carbon. The effect of using acclimated soil for the degradation of PAH's is illustrated in Table D-5. This study was done using soil from around a 20-year-old, creosote-treated telephone pole. These values represent the amount of the original PAH's remaining after 25 days; for example, with naphthalene, over 96 percent had disappeared. These results also indicate that the rate of breakdown is slower for the higher-molecular-weight PAH's.

DEGRADATION IN WATER

The same removal processes previously discussed for soil also apply to water. The basic processes which the chemicals could undergo are adsorption, volatilization, or decomposition, with the relative role of each process dependent on other constituents in the water and on environmental influences. In fact, biodegradation has been identified as the principal removal process, with the same microorganisms identified as being responsible for biodegradation in water as in soil. This is an intuitive observation since soil degradation primarily occurs in the soil pore water.

Volatilization and the adsorption of penta onto biological solids and volatilization were found to be negligible in both aerobic (Moos 1983) and anaerobic (Wukasch 1981 and Guthrie 1984) penta degradation processes. Penta removals of over 99 percent were observed in both processes, with biodegradation identified as the primary removal mechanism with minimal biomass absorption.

Researchers have been able to isolate bacteriological strains and to sustain rapid growth in a pure penta substrate under laboratory conditions. Chu (1972) identified a gram-variable bacillus designated as KC-3 as being able to reduce penta to

Table D-3
RATE OF MICROBIAL DEGRADATION OF PAH's

<u>Compound</u>	<u>No. of Rings</u>	<u>Microbial Degradation Rate Constant (hr⁻¹)</u>
Naphthalene	2	0.23
Anthracene	3	0.35
Benz(a)anthracene	4	0.005
Benz(a)pyrene	5	<0.0005

Table D-4
RATES OF MICROBIAL TRANSFORMATION OF PAH'S
IN SEDIMENT AT 20°C

	-----Half-Life (hr)-----			
	<u>No. of Rings</u>	<u>High PAH Level^a</u>	<u>Moderate PAH^b Level</u>	<u>Low PAH^c Level</u>
Naphthalene	2	3	5	>2,000
Anthracene	3	20	280	2,800
Benz(a)anthracene	4	100	7,000	>20,000
Benz(a)pyrene	5	1,300	>20,000	>20,000

^a Collected 0.5 km below coke effluent discharge.

^b Collected 0.2 km below petroleum storage depot.

^c Collected from uncontaminated forest stream.

Table D-5
PERCENT OF EACH CREOSOTE COMPONENT REMAINING AFTER 25 DAYS

<u>Compound</u>	<u>Residual (% of original)</u>
Naphthalene	3.8
2-Methylnaphthalene	28
1-Methylnaphthalene	30
Biphenyl	46
Acenaphthylene	66
Acenaphthene	47
Dibenzofuran	56
Fluorene	58
Phenanthrene	57
Anthracene	--
Carbazole	26
Fluoranthene	77
Pyrene	80
1,2-Benzanthracene	--
Chrysene	--

carbon dioxide and chloride. Finn (1983) developed a chemstat culture of *Arthrobacter* ATCC 33790 in water containing 130 to 300 ppm penta, which was shown to be a very effective seed for acclimating soil and water. Cserjesi (1972) identified *T. virgatum*, five *Trichoderma* species, and a *Penicillium* as organisms capable of PCP degradation to very low concentrations. All of these demonstrations of microorganisms able to use PCP as a sole carbon source prove the biodegradability of PCP.

These microorganisms already exist in trace amounts in the natural environment, in a Darwinian balance with millions of other species. To encourage the growth of those microorganisms capable of degrading wood-treating chemicals requires that they be provided with suitable environmental conditions and go through a gradual acclimation period. McGinnis (1984) was able to increase the application of PCP to 40 g of soil, from one mg to 90 mg over a 9-month period. Kirsch and Etzel (1973) and Wukasch (1981) used municipal activated sludge as the organism seed and gradually increased the penta feed from one mg/L to 20 mg/L over 90 days, while maintaining over a 99-percent removal efficiency. Wilson et al. 1983 identified the biotransformation of polyaromatic hydrocarbons (PAH's) and alkylated benzenes by acclimated subsurface microbial populations at a wood creosoting site. Vinbert (1970) measurement of the effluent from two creosote and penta wood-treating plants biological treatment system and found phenol reductions of over 99.6 percent. Bedient (1984) measured substantial microbial degradation and attenuation of organic contaminations at a creosoting plant's groundwater where nutrients and dissolved oxygen are present.

While researchers have found that very high biological removal efficiencies are possible with the controlled application of a wood-preserving wastewater to acclimated biocultures, these systems have been noted as being sensitive to nonuniform loadings with high strength or synthetic wastes, but very stable with low strength or with commingled wastewaters. Kirsch (1973) was the first to identify a biological sensitivity to feed changes with 20 to 40 ppm of a synthetic penta feedstream, but was able to achieve a consistent 99-percent penta reduction with the controlled feed of an authentic 15 ppm penta wastewater. Edgehill (1983) subjected a biological reactor to an 80-ppm step increase in synthetic penta concentration, which required 2 days to re-acclimate to the higher feed strength. Moos (1983) identified the biological kinetic parameters for penta aerobic treatment. The biological population was found to follow the same general kinetic relationships which apply to many other organic compounds, and had a specific growth rate of 0.0017 mg/day. A specific removal rate of one mg/g/h was measured for a 300-mg/L biomass, and a one-ppm reactor concentration. Higher reactor concentrations of 12 ppm were found to be inhibitory although

feed concentrations can be much higher. At a feed strength of 20 ppm penta, a 99.5-percent removal efficiency was noted with a 7.8-day solids retention time.

Guthrie (1984) conducted similar tests on anaerobic treatment systems, but the removal efficiency was so complete that kinetic parameters could not be established. With the batch feeding of a 5-ppm penta solution (equivalent to a continuous feed of over 50 ppm), reactor concentrations and effluents were below a 5-ppb detection limit for 10-, 20-, and 40-day reactors. This was well below a 600 ppb reactor inhibitory level.

White (1976) performed an extensive pilot plant test on wood-treating wastewater. Phenol was over 99 percent reduced at every operating level, even at organic loadings twice the typical loading used for domestic wastes. Activated sludge design parameters were recommended for an onsite biological treatment process to achieve the following removal efficiencies for the particular wastewater studied. These parameters include conservative allowances to accommodate the nonuniform feedrates and real-life onsite operating considerations.

PROJECTED REMOVAL EFFICIENCIES

COD removal efficiency = 70 to 80 percent
BOD removal efficiency = 90 percent
Phenol removal efficiency = 99 percent
Penta removal efficiency = 99 percent

RECOMMENDED DESIGN PARAMETERS

Average COD loading = 0.3 kg/day/kg MLSS
Maximum COD loading = 0.4 to 0.5 kg/day/kg MLSS
Average BOD loading = 0.1 kg/day/kg MLSS
Maximum BOD loading = 0.2 kg/day/kg MLSS
Average phenol loading = 0.01 kg/day/kg MLSS
Average penta loading = 1.62 gm/day/cu m
(0.1 lb/day/1,000 cu ft)
Maximum penta loading = 6.5 gm/day/cu m
(0.4 lb/day/1,000 cu ft)
Average hydraulic detention time = 60 hours
Minimum hydraulic detention time = 40 hours

Any trace residual penta in an effluent will continue to biodegrade and photodegrade in the environment. Cherry and Jessen (1982) investigated oxidation of chlorinated phenols by molecular oxygen and sunlight and found that pentachlorophenol was completely decomposed in three hours. Wong and Brosby (1978) studied the photolysis of penta in dilute water solution and found photodegradation products to be chlorinated phenols, tetrachlorodihydroxy-benzenes and nonaromatic fragments such as dichloromaleic acid. Prolonged irradiation

of penta degradation products yielded colorless solutions containing no ether extractable volatile materials, and evaporations of the aqueous layer left no observable polymeric residue such as humic acid. Pierce and Victor (1978) noted the formation of pentachloroanisole within the aquatic environment.

Lu et al. (1978) studied the fate of ^{14}C -labeled penta in a model ecosystem. Principal degradation products were tetrachlorohydroquinone, pentachlorophenyl acetate, and conjugates. Munakata noted that the photodegradation products were far less toxic than equivalent concentrations of penta.

Penta does not bioaccumulate in the environment and is rapidly eliminated by fish. Kobayashi (1974) measured a penta half-life of 10 hours in goldfish, and Braun (1976) indicated a half-life of 13 to 17 hours in rats and 72 to 84 hours in monkeys.

SUMMARY

Wood-preserving chemicals are stable compounds which are in use due to their ability to resist degradation in wood products. To be effective, this requires a strong absorption into the wood and high concentrations on the order of 9,600 to 12,000 ppm penta and 193,000 ppm creosote in treated wood. These compounds have been shown to also have a high affinity for soil absorption. At lower concentrations in soil and in water, and under suitable environmental conditions, these organic chemicals have been shown to be readily biodegradable by organisms already existing in the environment. By gradual acclimation and by control of the feedstream to avoid shock loading, well over 99-percent biodegradation has been achieved by both aerobic and anaerobic processes. This biodegradation efficiency is even much higher than that achieved with the usual constituents found in domestic sewage. Trace residuals have also been shown to photodegrade and to be rapidly excreted in both fish and in mammals, and not to bioaccumulate.

CVR32/036

APPENDIX E
REMEDIAL ACTION ALTERNATIVES

Appendix E
RI/FS AND REMEDIAL ALTERNATIVES

INTRODUCTION

While there is no apparent short-term health hazard to the public, McCormick & Baxter (M&B) is initiating a Remedial Investigation and Feasibility Study (RI/FS) for consideration of long-term mitigation of wood preservatives at the plant site.

The RI/FS will consider the potential long-term public health effects and environmental effects from the site. The RI/FS will determine "the lowest cost alternative that is technologically feasible and reliable and which effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare, or the environment" for site specific areas where there is the potential for uncontrolled offsite release of wood preservatives.

CONCEPTUAL ALTERNATIVES

The Remedial Investigation data, public health evaluation, and environmental analysis are elements of an endangerment assessment, which is used to determine the need for any remedial action. If the endangerment assessment proves the need for a remedial action, a limited number of conceptual alternatives are developed and subjected to initial screening based on three broad criteria: 1) cost, 2) effects of the alternative, and 3) acceptable engineering practices.

Conceptual alternatives usually fall into one or more of the following categories:

- o No action
- o Air pollution controls
- o Surface water controls
- o Leachate and groundwater controls
- o Gas migration controls
- o Waste and soil excavation and removal
- o Contaminated sediments removal or containment
- o In situ treatment methods
- o Disposal of water
- o Direct waste treatment
- o Disposal of excavated soils

Each conceptual alternative is discussed below in terms of its applicability to M&B.

NO ACTION

The National Contingency Plan requires that a "no action" response be considered for each of the site problems. No action would involve leaving in place contaminated soils, groundwater, and sediments. Contaminated groundwater would receive no treatment and would be allowed to migrate freely. Contaminant concentrations in the Willamette River are below aquatic life criteria and human health criteria.

AIR POLLUTION CONTROLS

Based on available site data and exposure studies, at present there is no evidence of any significant air pollution problem from site contamination sources addressed in this report. Air is a potential pathway for contaminant migration which must be addressed as part of any remedial action alternative. Air pollution controls may be required to allow safe implementation of certain remedial action alternatives (e.g., dust control during excavation).

SURFACE WATER CONTROLS

Surface water controls are designed to prevent the offsite migration of contaminated surface water. Surface water controls may also be used to prevent surface water from interfering with other remedial actions, (e.g., filling excavations). Surface water controls are also used to prevent surface water from running on or running off the area of contamination or to collect and treat contaminated runoff.

LEACHATE AND GROUNDWATER CONTROLS

Leachate and groundwater controls are designed to prevent or to minimize the contamination of groundwater by leachate generation as well as contaminant migration via groundwater. Leachate and groundwater controls can include the use of caps, containment barriers, and/or groundwater removal and treatment.

GAS MIGRATION CONTROLS

There is no evidence of a significant gas migration problem from site contamination sources addressed in this report. Gas migration controls could be incorporated into the construction of an onsite landfill or surface cap to mitigate future gas migration.

WASTE AND SOIL EXCAVATION AND REMOVAL

Excavation and removal of waste and contaminated soils may be implemented to eliminate or reduce the source of groundwater pollution, to reduce the threat of direct exposure to contaminated soils, and/or to aid in the implementation of another remedial action, such as the installation of a slurry

wall. The removal of underground debris is included in this conceptual alternative.

CONTAMINATED SEDIMENTS REMOVAL OR CONTAINMENT

This conceptual alternative is designed to prevent contact between contaminated sediments and surface water flow. As discussed previously, surface water runoff samples are now being collected and analyzed.

IN SITU TREATMENT METHODS

In situ treatment methods are designed to mitigate contamination problems without moving contaminated materials. Methods include contaminant destruction, treatment, and fixation.

DIRECT WASTE TREATMENT

Direct waste treatment can be implemented to destroy contaminants in, to remove contaminants from, or to stabilize and in some instances to fixate contaminants within solid, liquid, or gaseous waste streams. Incineration can completely decompose many types of organic contaminant molecules. Treatment systems can remove contaminants from liquid and gaseous waste streams. Direct waste treatment may be applicable to contaminated groundwater and possibly contaminated soils.

DISPOSAL OF WATER

This conceptual alternative is designed to dispose of water once the water has been collected or removed from the ground. Water can be disposed after or in lieu of treatment. The range of disposal options is affected by the degree of water treatment implemented prior to disposal.

DISPOSAL OF EXCAVATED SOILS

This conceptual alternative becomes applicable when contaminated soils are removed from the site. Excavated soils may be disposed of or treated onsite, or offsite in a RCRA-permitted facility.

SUMMARY OF CONCEPTUAL ALTERNATIVES

Table E-1 summarizes the potential site problems that would be significantly affected by the selection of a particular conceptual alternative. The table shows that a particular conceptual alternative will sometimes apply to more than one site problem.

Table E-1
IMPACT OF CONCEPTUAL ALTERNATIVES
ON EXISTING AND POTENTIAL SITE PROBLEMS

<u>Conceptual Alternative</u>	<u>Air Pollu- tion</u>	<u>Soil and Under- ground Debris</u>	<u>Sedi- ments</u>	<u>Ground- water</u>
No Action				
Air Pollution Controls	X			
Surface Water Controls	X	X		X
Leachate and Ground- water Controls	X	X		X
Gas Migration Controls				
Waste and Soil Exca- vation and Removal		X	X	X
Contaminated Sediments Removal or Containment				X
In Situ Treatment		X		X
Direct Waste Treatment		X	X	X
Disposal of Water				X
Disposal of Excavated Soils		X	X	

Note: X indicates that site problem would be positively affected by implementation of the conceptual alternative.

POTENTIALLY APPLICABLE REMEDIAL ACTION TECHNOLOGIES

A comprehensive list of remedial action technologies was developed from a literature review and knowledge of CERCLA remedial actions undertaken at other uncontrolled hazardous waste sites across the United States.

The remedial action technologies were grouped in terms of the conceptual alternatives previously described. A detailed list of specific technologies in each conceptual alternative is shown in Table E-2.

This section examines these technologies in order to identify the ones appropriate for further consideration. The examination is based on the current site characterization. Potentially acceptable technologies will be assessed in the RI/FS for more detailed screening.

Each category of remedial action technology is discussed in Table E-2. Table E-3 shows the rationale for eliminating any technology deemed inappropriate for further consideration.

AIR POLLUTION CONTROLS

Air pollution controls include the subcategories of surface capping and dust control measures. Surface caps also prevent surface water and precipitation from entering the zone of contamination and minimize the possibility of direct human contact with contaminated soils.

Several types of materials can be considered for use as surface caps. Of these, only chemical sealants and stabilizers were eliminated at this stage of analysis. They were rejected because the technology is unproven and durability has not been demonstrated.

Dust control measures include the use of polymers or water to suppress dust. Because air pollution is currently not a major site problem, these technologies cannot be considered as remedial actions alone. However, each may be used as a mitigating measure in conjunction with other technologies. For example, dust suppression might be necessary in the event that a remedial action involving excavation is implemented.

SURFACE WATER CONTROLS

Surface water controls include capping, grading, revegetation, and diversion and collection systems. Grading and revegetation do not sufficiently treat or isolate contaminants to be considered response actions alone, but may be used to supplement other technologies.

Table E-2
REMEDIAL ACTION TECHNOLOGIES AVAILABLE

A. Air Pollution Controls

- o Dust Control Measures
 - Polymers
 - Water

B. Surface Water Controls

- o Capping
 - Sprayed asphalt membrane
 - Portland concrete
 - Bituminous concrete (asphalt)
 - Gravel over geotextile
 - Loam over clay
 - Loam over synthetic membrane over sand
 - Loam over sand over synthetic membrane over clay
 - Chemical sealants and stabilizers
- o Grading
 - Scarification
 - Tracking
 - Contour furrowing
- o Revegetation
- o Diversion and Collection Systems
 - Dikes and berms
 - Ditches and trenches
 - Terraces and benches
 - Chutes and downpipes
 - Seepage basins
 - Sedimentation basins and ponds

C. Leachate and Groundwater Controls

- o Capping (Same as Item B)
- o Containment Barriers (vertical barriers)
 - Soil-bentonite slurry wall
 - Cement-bentonite slurry wall
 - Vibrating beam-asphalt wall
 - Grout curtains
 - Steel sheet piling
- o Horizontal Barrier (bottom sealing)
 - Block displacement
 - Grout injection

Table E-2
(continued)

- o Groundwater Pumping (Generally used with capping and treatment)
 - Well points
 - (a) Suction wells
 - (b) Jet ejector wells
 - (c) Submersible wells
 - Deep wells
 - o Subsurface Collection Drains
 - French drains
 - Tile drain
 - Pipe drain (dual-media drain)
- D. Gas Migration Control (Generally used with treatment)
- o Capping (Same as Item B)
 - o Gas Collection or Recovery
- E. Waste and Soil Excavation and Removal
- o Excavation and Removal
 - Backhoe
 - Front-end loaders
 - Scrapers
 - Pumps
 - Industrial vacuums
- F. Contaminated Sediments Removal or Containment
- o Sediment Removal
 - Mechanical Dredging
 - Hydraulic Dredging
 - Pneumatic Dredging
 - o Sediment Turbidity Controls and Containment
 - Curtain barriers
 - Cofferdams
 - Pneumatic barriers
 - Capping
- G. In Situ Treatment Methods
- o Hydrolysis
 - o Oxidation
 - o Reduction
 - o Soil aeration
 - o Solvent flushing
 - o Neutralization
 - o Polymerization
 - o Biodegradation
 - o Permeable treatment beds
 - o Organic chemical dechlorination

Table E-2
(continued)

H. Direct Waste Treatment

- o Incineration
 - Rotary kiln
 - Fluidized bed
 - Multiple hearth
 - Liquid injection
 - Molten salt
 - High-temperature fluid wall
 - Plasma arc pyrolysis
 - Cement kiln
 - Pyrolysis and starved combustion
 - Wet-air oxidation
- o Gaseous Waste Treatment
 - Activated carbon or other adsorbents
 - Flares
 - Afterburners
- o Onsite Treatment of Aqueous and Liquid Waste Streams
 - Biological Treatment Techniques
 - (a) Aerobic Biological Treatment Systems
 - Activated sludge
 - Trickling filters
 - Aerated lagoons
 - Waste stabilization ponds
 - Rotating biological discs
 - Fluidized bed bioreactors
 - (b) Anaerobic Biological Treatment Systems
 - Chemical Treatment Techniques
 - (a) Neutralization
 - (b) Precipitation
 - (c) Cyanide oxidation
 - (d) Organic chemical oxidation
 - (e) Hydrolysis
 - (f) Reduction
 - (g) Organic chemical dechlorination
 - (h) Molecular chlorine removal
 - Physical Treatment Techniques
 - (a) Flow equalization
 - (b) Coagulation/Flocculation
 - (c) Sedimentation
 - (d) Activated carbon
 - (e) Ion exchange
 - (f) Membrane processes
 - Reverse osmosis
 - Electrodialysis
 - Ultrafiltration

Table E-2
(continued)

- (g) Liquid/liquid extraction
- (h) Oil-water separator
- (i) Steam distillation
- (j) Air stripping
- (k) Steam stripping
- (l) Offsite Treatment
- (m) Filtration
- (n) Dissolved air flotation
- Offsite Treatment of Aqueous and Liquid Waste Streams
- o Solids Handling
 - Screens, hydraulic classifiers, scalpers
 - Centrifuges
 - Gravity thickening
 - Flocculation/coagulation, sedimentation
 - Belt filter press
 - Plate and frame filter press
 - Rotary drum vacuum filter
 - Drying or dewatering beds
 - Vacuum-assisted drying beds
- o Solids Treatment
 - Neutralization
 - Solvent extraction
 - Oxidation
 - Reduction
 - Composting
- o Solidification/Stabilization/Fixation
 - Cement based
 - Lime based
 - Thermoplastic
 - Organic polymer
 - Self-cementing techniques
 - Surface encapsulation
 - Classification
 - Solidification materials (i.e., flyash, polymers, sawdust)

I. Disposal of Water

- o Discharge to a publicly owned treatment works
- o Discharge to Willamette River
- o Spray irrigation
- o Industrial re-use
- o Shallow reinjection
- o Deep well injection

Table E-2
(continued)

J. Disposal of Excavated Soils

- o Onsite landfill disposal
 - o Offsite landfill disposal at a RCRA-permitted facility
 - o Surface impoundments
 - o Land application
 - o Waste piles
 - o Temporary storage
 - o Incineration at an offsite facility
-

/CVR64/036

LEACHATE AND GROUNDWATER CONTROLS

Leachate and groundwater controls include the subcategories of surface caps, vertical containment barriers, horizontal containment barriers, groundwater pumping, and subsurface collection drains. The use of surface caps is discussed above. Vertical containment barriers are used to contain soil contamination and to divert groundwater flow around the zone of contamination. Of the containment barrier technologies, the vibrating beam was eliminated because of the high potential for leakage and grout curtains were eliminated due to the presence of fine-grained soils. Horizontal containment barriers were eliminated because applicable technologies are still largely developmental.

Subsurface collection drains may be used to aid in the implementation of other remedial action responses. The potential for clogging of subsurface collection drains made the technology less desirable than other groundwater collection technologies and it was eliminated from further consideration as an independent response action.

Groundwater pumping can be used to remove groundwater contamination from the aquifer and to prevent contaminant migration. Both extraction and injection wells might have application.

GAS MIGRATION CONTROLS

Gas migration does not appear to be a problem at the site; therefore, gas migration controls will not be discussed as remedial actions. Gas migration controls may be incorporated into other remedial responses to prevent the development of a gas migration problem.

WASTE AND SOIL EXCAVATION AND REMOVAL

Soil excavation and removal technologies include the use of backhoes, front-end loaders, and scrapers. The appropriate technology depends on the depth of excavation and site-specific characteristics. All these technologies were retained for detailed analysis. Complete soil excavation and removal are proven technologies that could successfully eliminate the soil contamination.

CONTAMINATED SEDIMENTS REMOVAL OR CONTAINMENT

Sediment removal and containment technologies would be used if deemed necessary.

IN SITU TREATMENT METHODS

Because of the varied nature of the soil constituents, in situ treatment technologies may be neither feasible, environmentally sound, nor cost-effective. Further analysis

is necessary to determine whether any of the in situ technologies can be applied. Biodegradation and permeable treatment beds were retained for further consideration.

DIRECT WASTE TREATMENT

Direct waste treatment includes incineration, gaseous waste treatment, and treatment of aqueous and liquid wastes. Incineration can be applied to solid, liquid, and gaseous wastes. Onsite incineration of contaminated material was eliminated because of overwhelming technical and institutional constraints, and the combustion end-products associated with wood preserving chemicals. Gaseous waste treatment is not applicable and was not considered further.

Direct waste treatment of contaminated groundwater is accomplished by means of biological, chemical, or physical treatment technologies. Groundwater treatment may be implemented at an onsite treatment facility or an offsite commercial treatment facility. Biological treatment technologies are used primarily to remove organic contaminants. Chemical treatment technologies can be used to remove both organic and inorganic contaminants and/or to convert contaminants into less hazardous species. Physical treatment technologies are used to treat the waste stream and to aid in the implementation of other treatment technologies. All technologies were retained for further analysis.

Solids handling and treatment technologies fall into two separate subcategories, dewatering and solidification-stabilization-fixation. Solidification and dewatering technologies may be used to aid in the disposal of sludge from a groundwater treatment system or to aid in the disposal of sediments.

DISPOSAL OF GROUNDWATER

Disposal options for extracted groundwater include discharge to a publicly owned treatment works, discharge to the Willamette River, spray irrigation, shallow reinjection, and deep well injection.

Discharge to a publicly owned treatment works involves a discharge permit and user fees would be incurred. An NPDES discharge permit would be required for any river discharge but no user fees would be incurred. The treatment requirements for an NPDES permit are generally more stringent than the pretreatment requirements for a POTW discharge permit.

Spray irrigation is considered less feasible than other options because of the intensive site USC and the area's wet climate.

Industrial re-use of treated water involves the discharge of treated water into a nearby industries process or water supply line. The use of the treated water would have to be strictly monitored. No suitable industry was identified, so the option was eliminated from further consideration.

Shallow reinjection involves the reinjection of treated water into the shallow aquifer. Deep well injection involves the injection of treated or untreated water into a deep unusable saline aquifer. A detailed study will be required before the feasibility or desirability of deep well injection can be fully determined.

DISPOSAL OF EXCAVATED SOILS

Land disposal of soils includes landfills, surface impoundments, land application, waste piles, and temporary storage. Surface impoundment storage is generally applicable to sludge and liquid wastes, and is not commonly used for soil disposal. Land application was eliminated as a remedial action technology because of the presence of heavy metals in most of the contamination found at McCormick & Baxter. The use of waste piles was eliminated because it does not represent a permanent solution for any of the site problems. Disposal in onsite and offsite landfills was retained for further consideration.

Another option is the incineration of contaminated soils at a licensed hazardous waste facility. While onsite incineration was eliminated due to technical and institutional constraints, incineration at an offsite facility was retained for further consideration.

SUMMARY OF TECHNOLOGY IDENTIFICATION

Table E-3 summarized the technologies eliminated from further consideration as primary elements of remedial actions. The remaining technologies that will be considered further are listed in Table E-4.

PRELIMINARY ASSESSMENT OF APPLICABLE REMEDIAL TECHNOLOGIES

This section presents a preliminary assessment of applicable technologies as a preparation for assembling and screening example remedial action alternatives. The technologies are grouped into the conceptual alternatives presented earlier in this appendix. At this level of assessment, no attempt has been made to combine technologies within or between conceptual alternatives or to optimize for a single site area. Each technology is assessed discretely in this chapter without consideration of positive or negative effects when applied in combination with other technologies.

Table E-3
TECHNOLOGIES NOT DIRECTLY APPLICABLE TO
MCCORMICK & BAXTER

<u>Technology</u>	<u>Reason for Elimination</u>	<u>Comments</u>
<u>Dust Control Measures</u>		
Polymers	Does not treat or isolate contamination.	Not directly applicable to site problems. May be combined with other technologies such as excavation.
Water	Does not treat or isolate contamination.	Not directly applicable to site problems. May be combined with other technologies such as excavation.
<u>Capping</u>		
Chemical sealants and stabilizers	Subject to cracking. Potential for infiltration of precipitation. Complex application methods required.	
<u>Grading</u>		
Scarification Tracking Contour furrowing	May not in itself treat or isolate contamination. May result in increased airborne pollutant levels.	Not directly applicable to site problems. May be combined with other technologies.
<u>Revegetation</u>		
	Does not in itself treat or isolate contamination.	Not directly applicable to site problems. May be used for erosion control and aesthetic purposes after site cleanup is complete.

Table E-3
(continued)

<u>Technology</u>	<u>Reason for Elimination</u>	<u>Comments</u>
<u>Diversions and Collection Systems</u>		
Dikes and berms Terraces and berms	Does not in itself treat or isolate contamination.	May be combined with other technologies.
Seepage basins Sedimentation basins and ponds	Difficult to implement in small area.	
<u>Containment Barriers (Vertical)</u>		
Vibrating beam-- asphalt wall	High potential for leakage through the interlocks.	
<u>Containment Barriers (Horizontal)</u>		
Block displacement Grout injection	Technology is still developmental.	The installation of an onsite landfill would include horizontal containment in the form of a liner.
<u>Subsurface Collection Drains</u>		
French drains Tile drains Pipe drain (dual media drain)	Higher potential for clogging than with other groundwater collection technologies.	May be incorporated into the installation of a landfill.
<u>Gas Collection</u>		
Passive pipe vents Passive trench vents Active gas collection systems	Major gas releases have not been detected.	
<u>Waste and Soil Excavation and Removal</u>		
Pumps Industrial Vacuums	Not effective for removing compacted soils	

Table E-3
(continued)

Technology	Reason for Elimination	Comments
<u>Sediment Turbidity Controls and Containment</u>		
Curtain barriers Cofferdams Pneumatic barriers Capping	Sediment turbidity controls do not mitigate the primary contaminant transport problems.	Sediment turbidity may become a problem due to sediment removal options.
<u>Incineration (Onsite)</u>		
Rotary kiln Fluidized bed Multiple hearth Liquid injection Molten salt High temperature fluid wall Plasma arc pyrolysis Cement kiln Pyrolysis/starved combustion Wet air oxidation	Siting and permitting a hazardous waste incinerator at the site would be extremely difficult. Technology for mobile incinerators is new and relatively unproven. Major technical and economic concerns.	
<u>Gaseous Waste Treatment</u>		
Activated carbon Flares Afterburners	Major gaseous releases have not been detected.	May be used with an onsite landfill alternative or as part of an air stripping unit.
<u>Chemical Treatment Techniques</u>		
Cyanide oxidation Reduction Molecular chlorine removal Organic chemical dechlorination		Not applicable to constituents found onsite.
<u>Physical Treatment Technique</u>		
Ion exchange Air stripping Steam stripping		Not applicable to the high molecular weight constituents found onsite.

Table E-3
(continued)

Technology	Reason for Elimination	Comments
<u>Solids Handling</u>		
Screens, hydraulic classifiers, scalpers Centrifuges Gravity thickening Flocculation, sedimentation Belt filter press Plate and frame filter press	Technologies are usually used to prepare sludges and bulk liquids for landfill disposal. They are not applicable to current site conditions.	May be used as a post-treatment option in a groundwater treatment system.
Rotary drum vacuum filter Drying or dewatering beds Vacuum-assisted drying beds		
<u>Solids Treatment</u>		
Neutralization Solvent extraction Oxidation Reduction Composting	Heterogeneous nature of soil contamination makes this technology difficult to implement.	
<u>Solidification/Stabilization/Fixation</u>		
Cement-based Lime-based Thermoplastic Self-cementing techniques Surface encapsulation Classification Solidification materials (i.e., flyash, polymers, sawdust)	Technologies are usually used to prepare sludges and bulk liquids for landfill disposal. They are not applicable to current site conditions.	Not directly applicable to site conditions. In situ stabilization technologies for soil stabilization are discussed under in situ treatment.

Table E-3
(continued)

<u>Technology</u>	<u>Reason for Elimination</u>	<u>Comments</u>
<u>Disposal of Water</u>		
Industrial re-use	No suitable industry identified for re-use of water. Use of water would have to be strictly monitored.	
<u>Disposal of Excavated Soils</u>		
Surface impoundments	Generally used for liquid waste or sludge.	
Waste piles	Does not treat or isolate contamination.	
Temporary storage	Not a permanent solution.	May be used as part of another remedial technology.

/CVR64/045

Table E-4
TECHNOLOGIES POTENTIALLY APPLICABLE AT McCORMICK & BAXTER

Surface Water Controls¹

- o Capping
 - Sprayed asphalt membrane
 - Portland concrete
 - Bituminous concrete (asphalt)
 - Gravel over geotextile
 - Loam over clay
 - Loam over synthetic membrane over sand
 - Loam over sand over synthetic membrane over clay

Groundwater Controls

- o Containment Barriers
 - Soil-bentonite slurry wall
 - Cement-bentonite slurry wall
 - Grout curtains
 - Sheet-piling
- o Groundwater Pumping
 - Well points
 - (a) Suction wells
 - (b) Jet ejector wells
 - (c) Submersible wells
 - Deep wells

Waste and Soil Excavation and Removal

- o Backhoe
- o Front-end loaders
- o Scrapers

Contaminated Sediments Removal and Containment

- o Mechanical Dredging
- o Hydraulic Dredging
- o Pneumatic Dredging

¹ See Table E-2 for a complete list of all available technologies.

Table E-4
(continued)

In Situ Treatment Methods

- o Hydrolysis
- o Oxidation
- o Vitrification
- o Reduction
- o Soil aeration
- o Solvent flushing
- o Neutralization
- o Polymerization
- o Biodegradation
- o Permeable treatment beds
- o Solidification

Direct Waste Treatment

- o Onsite Treatment of Aqueous and Liquid Waste Streams
 - Biological Treatment Techniques
 - (a) Aerobic Biological Treatment Systems
 - Activated sludge
 - Trickling filters
 - Aerated lagoons
 - Waste stabilization ponds
 - Rotating biological discs
 - Fluidized bed bioreactors
 - (b) Anaerobic Biological Treatment Systems
 - Chemical Treatment Techniques
 - Neutralization
 - Precipitation
 - Organic chemical oxidation
 - Hydrolysis
 - Physical Treatment Techniques
 - (a) Flow equalization
 - (b) Coagulation/flocculation
 - (c) Sedimentation
 - (d) Activated carbon
 - (e) Membrane processes
 - Reverse osmosis
 - Electrodialysis
 - Ultrafiltration
 - (f) Liquid/liquid extraction
 - (g) Oil-water separator
 - (h) Steam distillation
 - (i) Filtration
 - (j) Dissolved air flotation

Table E-4
(continued)

- o Offsite Treatment

Disposal of Groundwater

- o Discharge to a publicly-owned treatment works
- o Discharge to Willamette River
- o Shallow reinjection
- o Deep well injection

Disposal of Excavated Soils

- o Offsite landfill disposal at a RCRA-permitted facility
- o Onsite landfill disposal
- o Incineration at an offsite facility

/CVR64/038

The preliminary assessment procedure considers only major impacts of the identified technologies. The procedure uses available data to allow preliminary conclusions to be drawn about effects and to facilitate comparisons between technologies before detailed analysis is performed. It also permits identification of sensitive general issues. This procedure catalogs only major impacts and does not rely on quantification since it is a preliminary screening procedure for identifying and eliminating infeasible technologies.

ASSESSMENT CRITERIA

Selection or rejection of applicable remedial technologies was based on the following general factors:

- o Physical site conditions that preclude, restrict, or promote the use of a specific technology
- o Chemical and physical characteristics of contamination that affect the effectiveness of a remedial technology
- o Inherent nature of a technology, such as performance record, reliability, and operating problems

To refine the relative applicability of each technology, the following additional criteria are applied in this appendix:

- o Technical Feasibility. Technical feasibility includes a general assessment of reliability, implementation capability, and safety. Reliability is assessed in categories of effectiveness, durability, and whether or not the technology is proven. Implementation capability is assessed in the categories of ease of installation, applicability to site conditions, time required to implement, and monitoring requirements. The safety category addresses the relative safety of a technology during operation and in the event of failure of the technology.
- o Environmental, Public Health, and Institutional Impacts. The evaluation and screening of remedial technologies from an environmental perspective addresses both short-term (construction-related) and long-term (operation-related) effects on the natural and manmade environment. Short-term effects considered during technology screening include odor, noise, air pollution, groundwater pollution, surface water pollution, wildlife habitat alteration, disposal of construction materials, and disruption of households, businesses, and services. Long-term effects considered during

technology screening include odor, noise, air pollution, surface water pollution, groundwater pollution, and wildlife habitat alteration; effect on any threatened and endangered species, or on the use of natural resources; alteration of parks, transportation, and urban facilities; relocation of households, businesses, or services; and aesthetic changes. Public health evaluations for each technology were made by judging exposure (short- and long-term) for each alternative. Institutional impacts were evaluated relative to political jurisdiction; surface water and groundwater standards; air quality, odor, and noise standards; land acquisition, land use restrictions, and zoning; and federal, state, or local laws or policies.

- o Cost. Cost comparison involves the comparison of costs for each technology. The comparison reflects relative rather than absolute costs and, wherever possible, takes into account life-cycle as well as capital costs. A negative assessment indicates that a technology is not cost-effective relative to other technologies and a positive assessment indicates that a technology is cost-effective relative to other technologies.

The applicable technologies are individually rated by assessing them with regard to the above criteria. The following scale is used for rating the technologies on the summary tables:

<u>Rating</u>	<u>Definition</u>
--	Extremely negative effects, even with mitigating measures; technology not worth further consideration
-	Negative effects that are not strong enough or certain enough to be sole justification for eliminating a technology; only moderate negative effects
o	Of very little apparent positive or negative effect, but inclusion can be justified for some special reason; little change from existing conditions
+	A positive or moderately positive benefit
++	An extremely positive benefit
*	Inappropriate to draw conclusions at this point in the evaluation process

DISCUSSION OF ASSESSED APPLICABLE REMEDIAL TECHNOLOGIES

Applicable technologies have been organized by conceptual alternative. Each technology by itself does not address all public health impacts of the site. To allow consistent ratings, each technology is rated relative to its impact or effectiveness in application to a specific hazard. This assumes that concerns regarding site hazards not addressed by a single action can potentially be mitigated through implementation of other technologies. The effect of combining technologies will be considered in subsequent chapters. Because a complete analysis of the effectiveness of a technology requires that its interaction with other technologies be examined, this chapter contains only general assessments of the remedial action technologies.

PRELIMINARY ASSESSMENT OF SURFACE WATER CONTROLS

CAPPING

The following capping technologies assume no soil removal, treatment, or other containment. Table E-5 shows the results of the preliminary assessment of capping technologies. Capping is used to eliminate human or animal contact with contaminated soils, to reduce water infiltration through contaminated soils, and to eliminate contaminant transport by surface water runoff and airborne emissions.

Sprayed Asphalt Membrane

This technology involves surface grading and spray application of a 1/4- to 1/2-inch-thick layer of asphalt to reduce infiltration and eliminate volatile and particulate emissions from the soil surface. It requires minimal material handling and a small labor force, and is easy to implement. However, the membrane is not very durable because it does not allow vehicular traffic, is photosensitive, has poor weather resistance, becomes brittle with age, and is susceptible to severe progressive cracking.

Portland Concrete

This technology involves surface grading and placement of a base course and a concrete slab with reinforcing steel to minimize infiltration and reduce emissions of volatiles and particulates from the surface soil. The technology is durable and resistant to chemical and mechanical damage. However, Portland concrete is susceptible to cracking from settlement and shrinkage. Installation requires the placement of forms and steel and the making of expansion joints. Proper design and installation generally results in relatively low maintenance costs.

Table E-5
PRELIMINARY ASSESSMENT OF SURFACE CAP TECHNOLOGIES

Technology	Evaluation			Comments
	Technical (see comment a.)	Environmental, Public Health and Institutional (see comment b.)	Cost (see comment c.)	
Sprayed Asphalt	-	o	o	a. Asphalt membrane is not durable.
Portland Cement Concrete	o	+	-	a. Concrete cap is relatively expensive to install properly.
Bituminous Concrete (Asphalt)	o	+	-	a. Susceptible to cracking. b. Asphalt cap would allow future site use.
Gravel Over Geotextile	+	+	+	a. Durable cover which will reduce dusting and withstand vehicular traffic.
Loam Over Synthetic Membrane Over Sand	-	o	o	a. Time consuming and difficult to implement. "Self-healing" capacity of clay is not present.
Loam Over Clay	-	o	o	
Loam Over Sand Over Synthetic Membrane Over Clay	-	o	-	a. Although construction is difficult and time consuming, this cap is more durable than other types of caps. b. Capital costs for this type of cap are high.

/CVR64/039

Bituminous Concrete (Asphalt)

This technology involves surface grading and placement of a base course and bituminous (asphalt) pavement to minimize infiltration. However, bituminous concrete is semiflexible, but is susceptible to cracking from settlement and shrinkage. Bituminous concrete is slightly photosensitive and tends to weather more rapidly than Portland concrete. This weathering generally contributes to operation and maintenance expenses that are greater than for Portland concrete.

Gravel Over Geotextile

This technology involves surface grading and compaction of native materials to minimize infiltration and reduce particulate emissions from the soil surface. The surface is covered with a geotextile and compacted gravel to provide a flexible surface course which can withstand heavy vehicular traffic.

Loam Over Clay

This technology involves surface grading and the placement of compacted clay to minimize infiltration and eliminate volatile and particulate emissions from the soil surface. The clay is covered with loam (top soil) to control moisture, protect the integrity of the clay layer, and allow revegetation. The cap requires only two passes to construct, but it contains only one impermeable layer. The clay has some self-healing properties but is subject to cracking due to dessication and will not carry vehicular traffic.

Loam Over Synthetic Membrane Over Sand

This technology involves grading and covering site soils with a blanket of sand overlain with an impermeable synthetic membrane that is covered by loam (top soil) to protect the synthetic liner and allow revegetation. The cap requires three passes to construct, and it contains only one impermeable layer. The synthetic membrane is susceptible to punctures, cracking, chemical degradation, and vehicular traffic.

Loam Over Sand Over Synthetic Membrane Over Clay

This technology involves grading and covering site soils with compacted clay and an impermeable synthetic membrane that is covered by sand. Overlying this sequence of materials is loam (top soil) to protect the membrane and allow

revegetation. The technology takes advantage of the self-healing properties of clay and the impermeable nature of synthetic membrane at correspondingly higher capital cost. Vehicular traffic would be restricted.

PRELIMINARY ASSESSMENT OF GROUNDWATER CONTROLS

Table E-6 summarizes this assessment.

CONTAINMENT BARRIERS

Reversed Gradient Barrier Walls

Impermeable barriers can be used to divert groundwater flow away from a waste disposal site or to contain contaminated groundwater migrating from a contaminated area. When no impermeable layer is available to seal the base of a containing wall, a reversed gradient can be induced to control vertical migration of contaminants or groundwater. Methods and materials used to construct reversed gradient barrier walls are discussed in the following sections.

Barrier walls are generally constructed from 5 to 40 feet deep. Since an impermeable layer in which a barrier wall could be keyed into has not been located at the Portland site, a wall constructed to 40 feet could still allow for migration of contaminants through the bottom of the isolation zone (under the wall). This migration problem would be exacerbated at the Portland site by seasonal fluctuations in the water table and contaminants that are heavier than water.

Additional remedial measures can be employed to mitigate the release of contaminants through the bottom of the isolation zone. These measures are based on the fact that the contaminants present in the alluvium will tend to migrate in the direction of groundwater flow. One way to reduce the amount of groundwater flowing out of the isolation area and under the barrier wall is to prevent infiltration of water into the isolation area. An impermeable cover over the isolated area would prevent rainwater from "flushing the contaminants out of the isolated alluvium.

Another strategy is to not only minimize flow out of the isolated alluvium, but to promote flow into the isolated zone. Lateral contaminant migration against such a groundwater gradient would be quite unlikely. One method for inducing this hydraulic gradient is to pump groundwater out of the alluvium inside the barrier wall. The groundwater would have to be treated and/or discharged to the city sewer or the Willamette River. A containment system consisting of a barrier wall and the pumping scheme just described (resulting in a higher hydraulic head outside the wall than inside) is called a reverse gradient barrier wall.

Table E-6
PRELIMINARY ASSESSMENT OF CONTAINMENT BARRIER TECHNOLOGIES

Technology	Evaluation			Comments
	Technical (see comment a.)	Environmental, Public Health and Institutional (see comment b.)	Cost (see comment c.)	
Soil-Bentonite Slurry Wall	-	-	o	<ul style="list-style-type: none"> a. Aquiclude is approximately 100 feet beneath site. Possibility of chemical degradation of slurry wall. b. Due to deep aquiclude, complete containment is very difficult.
Cement- Bentonite Slurry Wall	-	-	-	<ul style="list-style-type: none"> a. Aquiclude is approximately 100 feet beneath site. Cement-bentonite is simpler to install than soil-bentonite. Possibility of chemical degradation of slurry wall. b. Due to deep aquiclude, complete containment is very difficult. c. More expensive than soil-bentonite slurry wall.
Sheet-piling	-	-	-	<ul style="list-style-type: none"> a. Barrier is thin. Effectiveness of joint seal is difficult to determine. Susceptible to chemical attack. Possibility of wall corrosion.
Grout Curtain	-	-	-	<ul style="list-style-type: none"> a. Determining effectiveness of grout curtain would be difficult. Possibility of chemical degradation of curtain. b. Due to the depth of the aquiclude, complete containment is very difficult. c. Relatively high material costs.

Whether a hydraulic gradient is induced or not, some pumping of groundwater within the barrier wall is required. The hydraulically barricaded alluvium can be described as a bathtub. Should the "bathtub" fill with water (from seasonal changes in the groundwater table or from infiltration of precipitation) and begin to overflow, escaping groundwater will transport contaminants into the environment. Thus, some groundwater pumping is a required feature of any barrier wall/contaminant isolation scheme.

The types of barrier walls most often used in groundwater control include slurry walls, grout and polymer walls, and sheet pile walls.

Sheet Piling

The construction of a sheet piling cut-off wall involves driving interlocking piles into the ground with a suitable pile driver. Piles are usually 4 to 40 feet long and 15 to 20 inches wide. Prior to driving the sheet piling wall, the piles are assembled at their edge interlocks. The piles are then driven a few feet at a time over the entire length of the wall. Damage to the sheet piles can result from driving them through soil containing gravel, cobbles, and boulders, or into bedrock.

Sheet piles can be made of wood, precast concrete or steel. Wood is an ineffective water barrier however, and concrete is used primarily where great strength is required. Steel is usually the most effective in terms of groundwater cut-off and cost.

When first placed, steel piling cut-offs are also permeable. The edge interlocks are initially loose, but with time they fill with fine soil particles which eventually plug the interlocks. The time required to seal the interlocks depends on the texture of the soil. In coarse, sandy soils, the wall may never seal.

Grout Curtain

Grouting is the pressure injection of cementing or polymerizing fluids into a rock or soil body to seal and strengthen it. Once in place, these fluids set or gel into the rock and soil voids, greatly reducing the permeability of the grouted mass. Because a grout curtain can be three times as costly as a slurry wall, it is rarely used when groundwater has to be controlled in soil or loose overburden.

Bentonite Slurry Walls

Bentonite slurry walls have been demonstrated to be effective at isolating contamination in a number of contaminant

migration mitigation applications. A slurry wall is an impermeable barrier composed of bentonite, native soils, and small amounts of cement. The wall is constructed in a trench one to 5 feet wide that is kept open with a bentonite/water slurry. As excavation proceeds, the trench is back-filled with an essentially impermeable bentonite/soil/cement mixture that stabilizes in time to form the barrier.

Compatibility of bentonite slurry and the contaminants is an important issue in the application of slurry walls to hazardous waste containment. The slurry must not break down or change permeability characteristics. Compatibility tests have been conducted by Canonie Engineers using contaminated water from other wood treating plants and bentonite slurry with no observable change in physical or hydraulic characteristics. Further testing would have to be conducted to determine compatibility of McCormick and Baxter water and oils with the bentonite slurry.

A cement-bentonite slurry wall is a variant of the above that uses concrete instead of a bentonite/soil/cement mixture to displace the slurry. A cement-bentonite slurry wall is more expensive, but requires less space to construct and involves less complicated construction techniques.

GROUNDWATER PUMPING

Groundwater extraction wells can be located to intercept offsite movement or to reverse the direction of migration. Pumping requirements are determined by site hydrology, and sampling data reveal the extent of contamination and likely well locations and depth. Depending on constituent concentrations in the pumped water and discharge standards, treatment may be necessary. However, even if needed initially, it should be noted that treatment requirements diminish with time as the contamination in groundwater and soil is flushed and diluted by the influx of clean background groundwater.

Groundwater pumping would also be required for any soil excavation at or below the groundwater table. Due to soil permeability, a significant drawdown of the groundwater table would require extensive pumping.

Well Points

Well points are a common method of dewatering excavations and are used in groundwater pumping networks. A well point system generally consists of a series of closely spaced small-diameter wells, usually interconnected by a header pipe or a manifold. Pumps commonly used in well point systems include suction pumps, jet ejector pumps, and submersible pumps. Well points are best suited for use in low-

Table E-7
PRELIMINARY ASSESSMENT OF GROUNDWATER PUMPING TECHNOLOGIES

Technology	Evaluation			Comments
	Technical (see comment a.)	Environmental, Public Health and Institutional (see comment b.)	Cost (see comment c.)	
Well Points w/ Suction Pump System	o	o	+	a. Less expensive than other pumping systems.
Well Points w/ Jet Ejector Pump System	+	o	o	a. Jet ejector pumps can lift water from greater depths than can suction pumps.
Well Points w/ Submersible Pump System	-	o	-	a. Requires electrical power to many pumps. b. Higher O&M and capital costs than other well point pumping systems.
Deep Wells	-	o	-	a. Larger pumped volume than other pumping systems for a given drawdown.

/CVR64/041

permeability soils. Well points can be used at a variety of depths, depending upon the type of pump used.

Suction Pumps. In a suction pump system, each well point is connected to a central centrifugal suction pump. The well points are usually spaced from 2 to 6 feet apart, depending on the permeability of the saturated soil and on the desired depth of drawdown. The maximum effective lift that can be generated by a suction pump system is approximately 15 feet.

Jet Ejector Pumps. Jet ejector pumps are used in deeper well point systems requiring a greater lift than can be delivered by a suction pump system. Jet ejector pumps can lift water from depths of 100 feet or more. The jet ejector system requires an additional unit to recirculate water through the pump.

Submersible Pumps. Submersible pumps are centrifugal pumps placed inside each well casing below the water level. They require a 3-inch minimum well diameter. The lift capabilities of submersible pumps are generally limited only by the size of the pump that will fit in a given well.

Deep Wells

Deep wells are generally considered to be higher-capacity single-unit wells screened at greater depths than those found in a well point system. Submersible pumps and vertical turbine pumps are commonly used in deep wells. Deep wells are generally best suited for use in higher-permeability soils because of the need for a fairly large zone of influence for each well.

PRELIMINARY ASSESSMENT OF WASTE AND SOIL EXCAVATION AND REMOVAL

Waste and soil excavation and removal technologies are categorized by the procedures and equipment that are used (Table E-8). The assessment of waste and soil excavation and removal technologies assumes that excavated material is disposed of at a RCRA-permitted and -compliant landfill. This assessment is provided for consistency in this analysis; the choice of excavation methods is generally made by the contractor.

Backhoes, front-end loaders, and scrapers have all been used for excavations.

PRELIMINARY ASSESSMENT OF CONTAMINATED SEDIMENTS REMOVAL AND CONTAINMENT

The following technologies for the removal of contaminated sediments underwater are assessed in Table E-9. It is also

Table E-8
PRELIMINARY ASSESSMENT OF SOIL EXCAVATION TECHNOLOGIES

Technology	Evaluation			Comments
	Technical (see comment a.)	Environmental, Public Health and Institutional (see comment b.)	Cost (see comment c.)	
Backhoe	+	o	o	a. Reliable technology.
Front-end Loaders	o	o	o	
Scrapers	-	-	o	a,b. Effective only for onsite soil movement.

/CVR64/042

Table E-9
PRELIMINARY ASSESSMENT OF SEDIMENT REMOVAL TECHNOLOGIES

Technology	Evaluation			Comments
	Technical (see comment a.)	Environmental, Public Health and Institutional (see comment b.)	Cost (see comment c.)	
1. Mechanical Dredging				
Clamshell	+	-	o	a. Relatively easy to implement. b. Increases the turbidity of the creek flow.
Dragline	+	-	o	a. Relatively easy to implement. b. Increases the turbidity of the creek flow.
Backhoe	+	o	o	a. Relatively easy to implement.
2. Hydraulic Dredging				
Plain Suction	--			a. Results in the removal of large quantities of potentially contaminated surface water which then must be treated or disposed of.
Cutterhead	--			
Dustpan	--			
3. Pneumatic Dredging				
Airlift	--			a. Results in the removal of large quantities of potentially contaminated surface water which then must be treated or disposed of.
Oozer	--			

/CVR64/043

assumed that the excavated sediments will be disposed of at a RCRA-permitted landfill.

MECHANICAL DREDGING

Mechanical dredging technologies include the use of clamshells, draglines, and backhoes. Mechanical dredging technologies are easier to implement than are other types of dredging, minimize the mixing of water with the sediments, and they do not require the treatment or disposal of large quantities of potentially contaminated surface water. The use of clamshells and draglines will result in some suspension of sediments, with backhoes causing the least disturbance.

HYDRAULIC DREDGING

Hydraulic dredging technologies involve the pumping of sediments and some water and the subsequent separation and disposal of the sediments and water. Hydraulic dredging technologies include the use of suction devices, cutterheads, and dustpans. These technologies would remove the sediments; however, they would be difficult to implement because of the need for sedimentation basins and for disposal and treatment of the water.

PNEUMATIC DREDGING

Pneumatic dredging technologies involve the use of air to induce an upward flow of air, water, and sediments. Pneumatic dredging technologies include the use of airlifts and oozers. Large amounts of water are removed along with the sediments. That water must then be treated or otherwise disposed of.

PRELIMINARY ASSESSMENT OF IN SITU TREATMENT METHODS

The following assessment of in situ soil treatment technologies assumes that the process is implemented with no soil removal, other treatment, or containment technologies. This simplified overview is useful in determining if the technology has any application for the site. The determination of whether an in situ treatment technology would be functionally useful for actual site cleanup requires a further evaluation of how it can or cannot be effectively combined with other technologies. A preliminary assessment of these methods is presented in Table E-10.

HYDROLYSIS

Hydrolysis is a chemical reaction in which water reacts with another substance to form two or more new substances. It involves the ionization of the water molecule as well as the

Table E-10
PRELIMINARY ASSESSMENT OF IN SITU TREATMENT TECHNOLOGIES

Technology	Evaluation			Comments
	Technical (see comment a.)	Environmental, Public Health and Institutional (see comment b.)	Cost (see comment c.)	
Hydrolysis	-	--	o	<ul style="list-style-type: none"> a. Very difficult to implement without heat or catalysis. b. May result in hazardous side reactions. May worsen existing ground-water contamination problem.
Oxidation	-	--	o	<ul style="list-style-type: none"> a. Very difficult to implement on a heterogeneous system. b. May result in hazardous side reactions.
Vitrification	--	o	--	<ul style="list-style-type: none"> a. Technology is still developmental. It has not been demonstrated on a field scale operation.
Reduction	-	--	o	<ul style="list-style-type: none"> a. Very difficult to implement on a heterogeneous system. b. May result in hazardous side reactions.
Soil Aeration	-	--	o	<ul style="list-style-type: none"> a. Very difficult to implement on deep sub-surface contamination. b. May result in a gas migration problem.
Solvent Flushing	-	--	--	<ul style="list-style-type: none"> a. Solvents may not leach through the entire zone of contamination. b. Technology involves the use of potentially hazardous compounds. The solvents may actually contribute to the sub-surface contamination problem. c. Technology solubilizes constituents which were adsorbed onto the soil.

Table E-10
PRELIMINARY ASSESSMENT OF IN-SITU TREATMENT TECHNOLOGIES
(continued)

Technology	Evaluation			Comments
	Technical (see comment a.)	Environmental, Public Health and Institutional (see comment b.)	Cost (see comment c.)	
Neutralization	-	--	o	a. Very difficult to implement on a heterogeneous system. b. Involves the addition of potentially hazardous compounds to the zone of contamination.
Polymerization	--	o	o	a. Prohibitively difficult to implement on a heterogeneous, uncontrolled system.
Bioreclamation	++	+	o	a. Most effective at low to moderate concentrations. May require addition of nutrients, oxygen, and supplemental carbon source.
Permeable Treatment Beds	+	o	-	a. Technology requires shallow impermeable strata or liner to be effective.
Solidification	o	--		a. Long-term reliability has not been demonstrated for this application.

splitting of the compound hydrolyzed. It is effective in degrading some organic compounds, ionic salts, and organo-metallic compounds but is not an effective treatment for metals. In addition, some type of catalyst or heat addition is required for many of the desired reactions.

OXIDATION

Oxidation involves the transfer of electrons from contaminant compounds to desired oxidizing agents. Cyanide and organic compounds such as phenols, alcohols, and pesticides can be oxidized. Ozone, hydrogen peroxide, and chlorine are the major oxidizing agents used to treat waste. Oxidation can be used to treat a diverse range of organic wastes. Oxidation is difficult to implement in the solid phase due to the need for the diffusion of the oxidizing agent.

VITRIFICATION

In situ vitrification involves the melting of waste and soil in place to bind the waste in a glassy solid matrix. The melting is done by passing an electric current through the contaminated soils. Some organics would be destroyed by the high operating temperature. In situ vitrification, although still in development, is theoretically applicable to a wide range of soil contamination problems, including inorganic contamination. Control of air emissions and side reactions during the heating process may be a problem.

REDUCTION

Reduction involves the transfer of electrons from reducing agents to contaminant compounds. Reduction is most often used to convert hexavalent chromium to its trivalent form. Reduction is difficult to implement in the solid phase and is not compatible with oxidation processes that may be required to treat other site contaminants.

SOIL AERATION

Soil aeration involves the "saturation" of soil with air or some similar gas. It is generally used for surface or near-surface applications. It is difficult to aerate subsurface soils. Soil aeration is very effective treatment for volatile organic contamination but is not applicable for other types of contamination.

SOLVENT FLUSHING

Solvent flushing involves the use of a solvent to extract contaminants from soils. The elutriate is then gathered by wells or well points and the hazardous constituents are treated and/or disposed. Typical solvents used are water,

acids, ammonia, and chelating agents. In situ solvent extraction of hazardous wastes has not been demonstrated. In addition, solvent flushing is difficult to implement on non-homogeneous wastes. Total containment of the solvent waste stream would be extremely difficult.

NEUTRALIZATION

Neutralization is a process used to adjust the pH of a waste stream. Neutralization is accomplished by adding acidic material to alkaline wastes and alkaline material to acidic wastes. Neutralization techniques are often used to allow the use of other treatment technologies. Neutralization is an applicable treatment for areas of extreme pH, but would be difficult to implement on in-situ soils.

POLYMERIZATION

Polymerization involves the conversion of hazardous monomer compounds to nonhazardous and stable polymers. Polymerization is applicable to many organic compounds; however, each compound requires a different and rather refined polymerizing technique. Polymerization is not an applicable treatment for inorganic contamination, and therefore is not applicable to many of the constituents.

BIODEGRADATION

Biodegradation involves the use of microorganisms for in situ treatment of waste material. The microorganisms break down compounds via metabolic activity. Biodegradation can be effective in treating a wide range of organic contamination but is ineffective in treating inorganic contamination. The microorganisms must be adapted for specific contaminants by pilot-scale testing. Biodegradation is more difficult to apply to deep subsurface contamination or multi-compound contamination.

PERMEABLE TREATMENT BEDS

Permeable treatment beds involve the use of trenches filled with a reactive permeable medium to act as an underground reactor. They are used to treat contaminated groundwater or leachate via the precipitation process. Permeable treatment beds are applicable in relatively shallow aquifers, since the trench must be constructed down to an impermeable layer. They can also be constructed with granular material laid over an impervious liner.

The materials used in permeable bed reactors include:

- o Limestone or crushed shell for metals removal

- o Activated carbon for nonpolar organics removal
- o Alauconitic green sand for heavy metals removal
- o Zeolites and synthetic ion exchange resins to remove solubilized heavy metals
- o Sodium hypochlorite to remove cyanide

Because of the varied nature of the constituents onsite and the lack of a suitable area, it would be extremely difficult to employ this technology effectively.

SOLIDIFICATION/STABILIZATION

Stabilization is the use of chemical fixants to physically stabilize contaminated soils. The chemical fixants are applied through probes that can be drilled up to 45 feet into the soil. Few chemical stabilizations have been done and the technology is unproven. Solidification involves the use of materials to absorb liquid and/or to solidify the matrix. For both stabilization and solidification, testing must be done to determine the leachability of the final product.

PRELIMINARY ASSESSMENT OF TREATMENT OF AQUEOUS AND LIQUID WASTE STREAMS

Individual treatment technology assessments are based on how well the technologies remove the specific contaminants for which they are designed and on whether they interfere with the implementation of any other technology (see Table E-11).

AEROBIC BIOLOGICAL TREATMENT SYSTEMS

Biological treatment systems are usually classified on the basis of whether they are aerobic or anaerobic. By definition, aerobic treatment systems require air to function while anaerobic treatment systems function in the absence of air.

Aerobic treatment systems include the following technologies:

- o Activated sludge
- o Trickling filters
- o Aerated lagoons
- o Waste stabilization ponds (both aerobic and anaerobic)
- o Rotating biological discs

Table E-11
PRELIMINARY ASSESSMENT OF GROUNDWATER TREATMENT TECHNOLOGIES

Technology	Evaluation				Comments
	Technical (see comment a.)	Environmental, Public Health and Institutional (see comment b.)	Operating Cost (see comment c.)	Capital Cost (see comment c.)	
Aerobic Treatment Systems					
Activated Sludge	+	+	+	-	a. Well proven technology. b. Removes many toxic compounds. c. Low operating, high capital cost.
Trickling Filters	o	+	+	-	c. Low operating, high capital cost.
Aerated Lagoon	+	-	+	-	a. Requires operating area larger than site. b. Large, open area of hazardous materials during operation. c. High capital, low operating costs.
Waste Stablization Ponds	+	-	+	-	Same comments as for aerated lagoons.
Rotating Bio-logical Discs	--	-	+	--	a. Historically has had operating difficulties. b. Process is self-contained. Removes most organics. c. Low operating, high capital costs.
Fluidized Bed Bioreactors	o	o	+	-	Same consideration as for rotating biological discs.

Table E-11
PRELIMINARY ASSESSMENT OF GROUNDWATER TREATMENT TECHNOLOGIES
(continued)

Technology	Evaluation				Comments
	Technical (see comment a.)	Environmental, Public Health and Institutional (see comment b.)	Operating Cost (see comment c.)	Capital Cost (see comment c.)	
Anaerobic Treatment Systems	+	o	+	-	a. Sensitive to heavy metals. c. High capital, high energy costs.
Chemical Treatment Techniques					
Neutraliza- tion	++	o	o	o	a. Relatively easy to implement. Well proven technology.
Precipitation	++	o	+	-	a. Well proven for the removal of heavy metals. c. High capital, low operating costs.
Organic Chemical Oxidation	+	+	-	+	a. Well proven for the removal of some organics. b. Destroys hazardous material. c. Low capital, high operating costs.
Hydrolysis	--				

Table E-11
PRELIMINARY ASSESSMENT OF GROUNDWATER TREATMENT TECHNOLOGIES
(continued)

Technology	Evaluation				Comments
	Technical (see comment a.)	Environmental, Public Health and Institutional (see comment b.)	Operating Cost (see comment c.)	Capital Cost (see comment c.)	
Flow Equalization	++	o	+	o	a. Easy to implement. Required for many processes. c. Low maintenance costs.
Coagulation/ Flocculation	--	o	o	o	a. No suspended solids in groundwater. Technology is not directly appli- cable.
Sedimentation	--				a. Technology is not ap- plicable for site. NOTE: Both sedimenta- tion and flocculation are used as part of precipitation tech- nology.
Activated Carbon	++	o	-	o	a. Removes most organic compounds. c. Uses large amounts of carbon.
Membrane Processes					
Reverse Osmosis	o	o	-	-	c. Expensive equipment and pretreatment needed. Process is power intensive.

Table E-11
PRELIMINARY ASSESSMENT OF GROUNDWATER TREATMENT TECHNOLOGIES
(continued)

Technology	Evaluation				Comments
	Technical (see comment a.)	Environmental, Public Health and Institutional (see comment b.)	Operating Cost (see comment c.)	Capital Cost (see comment c.)	
Electrodialysis	o	o	-	-	c. Expensive equipment. Pretreatment is needed. Process is power intensive.
Ultrafiltration	o	o	o	-	c. Expensive equipment and pretreatment is needed.
Liquid/Liquid Extraction	-	-	-	-	a. Organics concentration may be too low for efficient operation. b. Process uses potentially hazardous solvents. c. Requires expensive equipment and uses large amounts of chemicals.
Oil-Water Separator	++	+	+	+	
Filtration	-	o	+	o	a. No suspended solids in groundwater. Technology is not directly applicable. May be required as pretreatment. c. Very low operating costs.

Table E-11
PRELIMINARY ASSESSMENT OF GROUNDWATER TREATMENT TECHNOLOGIES
(continued)

Technology	Evaluation				Comments
	Technical (see comment a.)	Environmental, Public Health and Institutional (see comment b.)	Operating Cost (see comment c.)	Capital Cost (see comment c.)	
Dissolved Air Flotation	--				a. Not applicable.
Offsite Treatment at a Commercial Facility	-	o	--	o	a. No existing nearby facilities to handle contaminants. b. User fees and transporta- tion costs to commercial facilities are usually very high.

/CVR64/037

- o Fluidized bed bioreactors (may be aerobic or anaerobic)

Aerobic treatment systems remove biodegradable organic compounds, bioadsorb a limited amount of metals and nondegradable organic compounds, and oxidize reduced compounds. Penta and creosote have been shown to be very biodegradable in controlled systems with uniform feedstreams. Each of the aerobic biological processes will perform generally the same functions; however, each process may be more or less efficient for a particular application and will normally require bench testing to optimize the selection.

Only biological treatment is able to convert the wood-treating chemicals to innocuous end-products and to effect safe ultimate disposal. In fact, the advantages afforded by the ultimate biodegradation of potentially hazardous compounds has made EPA and the Congressional Office of Technology Assessment (OTA) encourage the use of biological treatment where practical and have labelled it as an innovative technology for hazardous wastes.

Researchers have demonstrated 99+ percent removal efficiencies under controlled aerobic and also anerobic conditions. The stability of the biological process has been shown to be further enhanced by attenuation with other wastestreams.

Onsite treatment would not benefit from attenuation and therefore would be more sensitive to high-strength shock loads. However, any onsite biological treatment system would need such a large land area that EPA chose not to require their installation onsite in their 1979 Development Document for Timber Products Processing.

Discharge to a POTW has many advantages where it is viable. It is the standard practice for the treatment of biodegradable wastewaters and offers the advantages of substantial attenuative capacity, little spatial requirement, substantial economies-of-scale, and reliability over an onsite treatment system. The degradation of phenol and penta has also been shown to be more complete than normal domestic sewage. Lastly, the combination of aerobic degradation plus anaerobic sludge digestion found at many POTW's, would assure an extremely high destruction efficiency. Each process has been shown to be capable of 99-percent removal efficiencies, and their series application would further improve the singular removal efficiencies.

Activated Sludge

This technology is an effective way to remove most organic compounds, provided that a uniform feed strength is

maintained. Attenuation with other wastes is often beneficial in providing nutrients and system dampening.

Trickling Filters

Trickling filters are media-packed columns similar to activated sludge in the removal of organic compounds, but will often have lower removal efficiencies and be more prone to nonuniform loading.

Aerated Lagoons

Aerated lagoons are large complete-mixed basins in which organic wastes are biodegraded by organisms similar to an activated sludge system. The large basin volume helps to dampen feedstream variations.

Waste Stabilization Ponds

Waste stabilization ponds are similar to aerated lagoons except that air is not artificially diffused. Waste stabilization ponds require the largest land area of any of the biological systems.

Rotating Biological Disks

The rotating biological disk technology treats organic wastes by fixed-film biological growth. The biological mass is contained on a series of disks. These disks are partially immersed in a tank containing the waste material. The disks are then rotated, providing alternate immersion and aeration. This technology is the most sensitive to feedstream variations.

Fluidized Bed Bioreactors

This technology implements the processes of biological treatment by using a fluidized bed reactor. A fluidized bed reactor is a solid phase reactor. The reactor medium is usually some type of finely powdered or granular material. Air or water is passed through the reactor medium, creating a fluidized effect. As with most biological treatment processes, fluidized bed bioreactors are more effective treating organic contamination than inorganic contamination.

ANAEROBIC BIOLOGICAL TREATMENT SYSTEMS

Anaerobic treatment systems remove organic compounds by bacterial conversion to carbon dioxide, methane, and sometimes hydrogen sulfide. Anaerobic treatment systems will destroy biodegradable compounds. The methane gas produced can be recovered for useful applications. Anaerobic systems

require long detention times and are capital intensive treatment systems.

NEUTRALIZATION

Neutralization is used to treat waste streams that are alkaline or acidic in order to meet pH discharge standards. Neutralization is often used in conjunction with other treatment technologies as a pre-treatment or post-treatment remedial action. Neutralization is implemented by adding acidic reagents to alkaline streams or by adding alkaline reagents to acidic streams.

PRECIPITATION

Coagulation with lime and/or polyelectrolytes has proven to be effective in removing emulsified oils thereby reducing BOD along with phenol and penta concentrations associated with the oils. Emulsified oil and grease is aggregated by chemical addition through the process of coagulation and/or acidification.

Middlebrooks and Pearson (1968) found that 79 percent of the BOD and 80 percent of the COD in this type of wastewater could be removed by chemical coagulation with the addition of approximately 2,000 mg/L of lime and alum. However, the volume of sludge produced was almost 40 percent. Dust, et. al. (1972) found that 0.75 to 2.0 gm/L of lime appeared to be an optimum dosage for reduction of COD by an average of 96 percent and PCP by an average of 93 percent. The volume of sludge produced by adding 2.0 gm/L of lime with no polyelectrolyte was equal to 30 percent of the total volume of the raw waste. However, when 5 mg/L polyelectrolyte was added with the lime, the sludge compacted to a final volume of 5 percent. Although the treatment efficiencies were high, the problem of sludge disposal would suggest that another type of treatment for breaking the emulsion might be more feasible.

ORGANIC CHEMICAL OXIDATION

Organic oxidation is often accomplished by using wet air oxidation (WAO). The WAO process is a liquid-phase combustion implemented through the addition of high-pressure air and sometimes a catalyst at elevated temperatures. The reaction products are steam, nitrogen gas, carbon dioxide, and an oxidized liquid waste stream. Supercritical water (water above its critical temperature and pressure) may also be used as an oxidizing agent.

Another form of organic oxidation is chemically-induced oxidation, accomplished by adding an oxidizing agent to the waste stream. Commonly used chemical oxidants include

hydrogen peroxide and chlorine potassium permanganate. Chemical oxidation is effective only if the reaction produces less hazardous constituents.

Successful oxidation of phenolics by chlorine was reported by the American Petroleum Institute (1969). Apparently, low dosages of chlorine produce chlorophenolics which produce taste and odor problems. When a large excess of chlorine is supplied (5 grams/L per 100 mg/L phenol), the benzene ring is broken and a harmless nonphenolic compound is created.

Dust, et. al. (1972) achieved 70 to 96 percent removal of phenols from wood preserving wastewater by lime coagulation with 0.75 gm/L lime followed by chlorination of the supernatant with 2.0 gm/L chlorine. Research completed by Middlebrooks and Pearson (1968) indicated that 30 percent COD reduction and 90 to 95 percent phenol reduction is achievable with a 1.7 gm/L chlorine addition. The theoretical ratio of chlorine to phenol for complete destruction is 6:1; however, other organic compounds present in the wastewater necessitate as much as 50 parts chlorine to one part of phenol. Also, the presence of ammonia was noted to retard the reaction of chlorine and phenols. The ratio of chlorine to ammonia to oxidize the ammonia is 10:1.

Although the treatment efficiencies by chemical oxidation can be high, the extremely high doses of chlorine required, along with the risk of forming more toxic reaction end products, suggest that other treatment alternatives would be more feasible.

As with cyanide oxidation, UV/ozonation can also be used to achieve organic oxidation. Ozonation is an effective treatment for chlorinated hydrocarbons, alcohols, chlorinated aromatics, and pesticides, as well as cyanides.

HYDROLYSIS

Hydrolysis is a chemical reaction in which water reacts with another substance to form two or more new substances. The reaction involves the ionization of the water molecule as well as the splitting of the hydrolyzed compound. The major constituents of penta and creosote would not undergo hydrolysis reactions naturally, and catalysis would be required to increase the reaction rate above what is naturally occurring.

FLOW EQUALIZATION

Flow equalization involves the use of basins or tanks to control and lessen flow and concentration fluctuation. The technology is used as a pretreatment operation for many biological, chemical, and physical treatment processes. Flow equalization can be implemented as in-line equalization, or as off-line equalization, in which only the flow above a specified amount is diverted to the equalization and is fed back into the main stream at low flow.

COAGULATION/FLOCCULATION

Coagulation/flocculation involves the addition of a coagulant such as lime, alum, or polymer to coagulate dispersed suspended particles so they will settle more readily than individual particles. It is promoted by gentle stirring with slow-moving paddles. The technology may be used as part of a precipitation process but would not be used by itself because of the apparent absence of suspended solids in the groundwater.

SEDIMENTATION

Sedimentation is the gravity settling of solids particles suspended in a liquid. It is generally used with precipitation and flocculation.

ACTIVATED CARBON

Activated carbon is used in the granular or powdered form to remove contaminants from aqueous wastes via carbon adsorption. The technology is primarily used to remove those organic compounds that are not treatable by biological treatment. Activated carbon can also be used to protect the overloading of biological treatment systems. In studies conducted by Dust and Thompson (1972), 96 percent of the phenols and 80 percent of the COD were removed from creosote wastewater at a carbon dosage of 8 gm/L. Similar results were obtained in tests using pentachlorophenol wastewater. Activated carbon is also tolerant of flow and concentration variations. However, operating costs are high, due to carbon usage rates, and the loaded carbon requires disposal or regeneration. Carbon adsorption is, therefore, usually suitable only for small quantities of water or for very stringent removal requirements.

Other adsorbants are also available to remove soluble constituents. Researchers have found bentonite clay plus a polymeric adsorbant such as amberlite XAD-4 to be effective in removing constituents from wastewater acidified to pH 4.

MEMBRANE PROCESSES

Membrane processes involve the use of semi-permeable membranes to remove contaminants from aqueous waste streams. Relatively clean product water is produced, leaving behind a more concentrated waste stream equal to 10 to 50 percent of the original volume which requires further treatment or disposal. Membrane processes are highly susceptible to fouling and often require extensive pretreatment, even with wastes that are relatively low in contaminants. Membrane processes in use today include reverse osmosis, electrodialysis, and ultrafiltration.

Reverse Osmosis

Reverse osmosis passes the waste stream through a semi-permeable membrane at high pressure. Typical membranes are impermeable to most inorganic and some organic compounds.

Electrodialysis

Electrodialysis is accomplished by using an electric current to aid in the separation of substances that ionize in solution. Semi-permeable membranes are placed between electrodes to isolate and separate constituents as anions (-) or cations (+). Electrodialysis is generally effective for most inorganic species, but does not remove organics. Organics may in fact degrade the electrodialysis membranes.

Ultrafiltration

Ultrafiltration involves the use of microscopic filters to remove wastes from aqueous streams. The technology is generally effective at removing all suspended solids and some dissolved molecules with a molecular weight greater than 1,000.

LIQUID/LIQUID EXTRACTION

The liquid/liquid extraction technology involves the use of solvents to extract contaminants from the aqueous phase. Solvents such as fuel oil and/or amyl alcohol still bottoms are vigorously mixed with the aqueous phase, removing certain contaminants. The solvent phase is then allowed to separate from the aqueous phase and is treated or disposed of. The technology requires the use of flow equalization and free-oil separation for consistent operation. Precautions are necessary to ensure the safe use of potentially hazardous solvents and the disposal of the hazardous solvent phase effluent.

OIL-WATER SEPARATION

McCormick & Baxter currently operates a gravity oil/water separation unit to recover penta and creosote from waste process water. Free oil is effectively removed, but an emulsified residual of 10 to 20 ppm will remain.

FILTRATION

Filtration is a physical method for separating solids from liquids, but is not effective for the removal of dissolved solids. It could be used as a pre-treatment and post-treatment operation for many of the other treatment technologies.

DISSOLVED AIR FLOTATION

Dissolved air flotation removes insoluble components such as solids and/or oil and grease from an aqueous phase. Dissolved air flotation (DAF) produces approximately the same effluent as a gravity oil/water separator, and its additional cost would be warranted only with feedstreams with high oil and grease concentrations.

OFFSITE TREATMENT AT A COMMERCIAL FACILITY

An alternative to constructing an onsite treatment plant would be to transport the contaminated groundwater to a commercial treatment facility. There are no commercial treatment facilities in the local area.

PRELIMINARY ASSESSMENT OF DISPOSAL OF WATER

The amount of water treatment necessary for a particular groundwater disposal technology is considered during the technical assessment. The preliminary assessments of groundwater disposal technologies are shown in Table E-12.

DISCHARGE TO A PUBLICLY-OWNED TREATMENT WORKS

This technology would be implemented by discharging the water into a publicly-owned treatment works (POTW). Only biological treatment is able to convert the wood-treating chemicals to innocuous end-products and to effect safe ultimate disposal. In fact, the advantages afforded by the ultimate biodegradation of potentially hazardous compounds has made EPA and the Congressional Office of Technology Assessment (OTA) encourage the use of biological treatment where practical and have labelled it as an innovative technology for hazardous wastes.

Researchers have demonstrated 99+ percent removal efficiencies under controlled aerobic and also anerobic conditions. The stability of the biological process has been shown to be further enhanced by attenuation with other wastestreams.

Onsite treatment would not benefit from attenuation, and therefore would be more sensitive to high-strength shock loads. However, any onsite biological treatment system would need such a large land area that EPA chose not to require their installation onsite in their 1979 Development Document for Timber Products Processing.

Discharge to a POTW has many advantages where it is viable. It is the standard practice for the treatment of biodegradable wastewaters and offers the advantages of substantial attenuative capacity, little spatial requirement,

Table E-12
PRELIMINARY ASSESSMENT OF GROUNDWATER DISPOSAL TECHNOLOGIES

Technology	Evaluation			Comments
	Technical (see comment a.)	Environmental, Public Health and Institutional (see comment b.)	Cost (see comment c.)	
Discharge to a Publicly Owned Treatment Works	++	o	+	a. Easy to implement. Makes use of attenuative capacity to enhance removal efficiencies. b. Requires permitting to implement. c. Must pay user fees.
Discharge to Willamette River under an NPDES permit	-	-	o	a. Must meet discharge criteria. Must pump water from site to river. b. Requires permitting to implement.
Spray Irrigation	--	-		a. Not feasible due to wet climate and limited land area.
Shallow Reinjection	o	o	o	
Deep Well Injection	--	--	-	a. Requires drilling of deep well. Does not require pretreatment. b. Contaminants remain in the environ- ment. The existence of a sufficiently isolated and unusable deep aquifer has not been demonstrated.

/CVR64/046-1

substantial economies-of-scale, and reliability over an on-site treatment system. The degradation of phenol and penta has also been shown to be more complete than normal domestic sewage. Lastly, the combination of aerobic degradation plus anaerobic sludge digestion found at many POTW's, would assure an extremely high destruction efficiency. Each process has been shown to be capable of 99-percent removal efficiencies, and their series application would further improve the singular removal efficiencies.

DISCHARGE TO WILLAMETTE RIVER

This technology involves the discharge of pumped groundwater into the Willamette River under an NPDES permit. The treatment requirements for the NPDES discharge permit are generally more stringent than the requirements for a POTW.

SPRAY IRRIGATION

This technology involves the use of treated groundwater to irrigate fields in the surrounding area. The wet climate in the area makes this technology infeasible.

SHALLOW REINJECTION

This technology involves the reinjection of treated groundwater into the shallow aquifer. This would replace the pumped groundwater with a higher quality water and would minimize drawdown of the water table.

DEEP WELL INJECTION

This technology involves the injection of groundwater into an unusable deep saline aquifer. This technology would require little or no groundwater pretreatment. Its feasibility would depend on whether there is a deep saline aquifer suitably isolated from the rest of the environment and whether such disposal could be permitted. The existence of a suitable aquifer has not been demonstrated and deep well injection is coming under increased regulatory restrictions.

PRELIMINARY ASSESSMENT OF DISPOSAL OF EXCAVATED SOIL

Excavation and disposal would remove and contain the soil in onsite or in a licensed offsite treatment, storage, and disposal (TSD) facility. This approach could be used on selected high-strength surface areas or for in-depth soils.

Because the average groundwater depth in the alluvium is approximately 20 feet, excavation at or below this depth would require extensive groundwater control. Lateral groundwater flow could be controlled through the use of hydraulic barriers used in conjunction with pumping of

perimeter wells. Pumping rates would be excessive due to the porosity of the soil and the proximity of the Willamette River. Free liquids that drain from the alluvium as excavation proceeds would have to be collected for treatment and/or discharge to a POTW.

LANDFILL DISPOSAL AT AN OFFSITE FACILITY

Once the soil is excavated, it could be disposed of in a landfill meeting RCRA requirements (40 CFR 264.300). Three potential operating and RCRA-permitted sites for offsite disposal have been identified. These are the Chem Waste Facility in Arlington, Oregon, the ESI facility in Mountain Home, Idaho, and the U.S. Pollution Control facility in Grassy Mountain, Utah.

CONSTRUCTION OF AN ONSITE LANDFILL DISPOSAL

This technology involves the construction of an onsite, secure waste landfill. Material is excavated and clean backfill imported and placed so that the bottom liner of the landfill can be located above the seasonal high water table. A bottom liner is then installed according to the latest available technologies. A leachate detection system is installed between the liners and a leachate collection system installed above the top liner.

INCINERATION AT AN OFFSITE FACILITY

This technology involves the destruction by incineration of the soil-contaminant matrix at an approved offsite incinerator. Incineration will destroy most forms of soil contamination with the exception of heavy metals. Incineration may not render the soil-contaminant matrix technically nonhazardous and that material may still require hazardous waste disposal.

SUMMARY OF PRELIMINARY TECHNOLOGY ASSESSMENT

A technology is considered to have passed through the preliminary assessment procedure if it did not receive a double negative (--) mark in any one of the assessment categories. The preliminary assessment procedure is designed only to screen out those technologies that are not likely to work. The screened technologies generated from this section may be used in example remedial action alternatives. In developing the example remedial action alternatives, no attempt will be made to incorporate all possible technologies. Detailed design work may indicate that technologies that passed preliminary assessment but were not used in an example alternative may have technical, environmental/institutional, or cost benefits greater than the benefits of those technologies used in the example alternatives. Table E-(13) is a list of all technologies that have passed the preliminary assessment.

Table E-13
PRELIMINARY ASSESSMENT OF SOIL DISPOSAL TECHNOLOGIES

Technology	Evaluation			Comments
	Technical (see comment a.)	Environmental, Public Health and Institutional (see comment b.)	Cost (see comment c.)	
Offsite Landfill	+	-	-	c. High capital cost for landfill construction.
Onsite Landfill	-	-	+	a. Construction of onsite landfill is difficult. Requires extensive monitoring for many years. c. Costs less than offsite landfill disposal for large volumes of material.
Offsite	-	+	-	a. Heavy metals are not destroyed. b. Destroys some types of contamination. c. Costs more than landfill disposal.

/CVR64/046-2